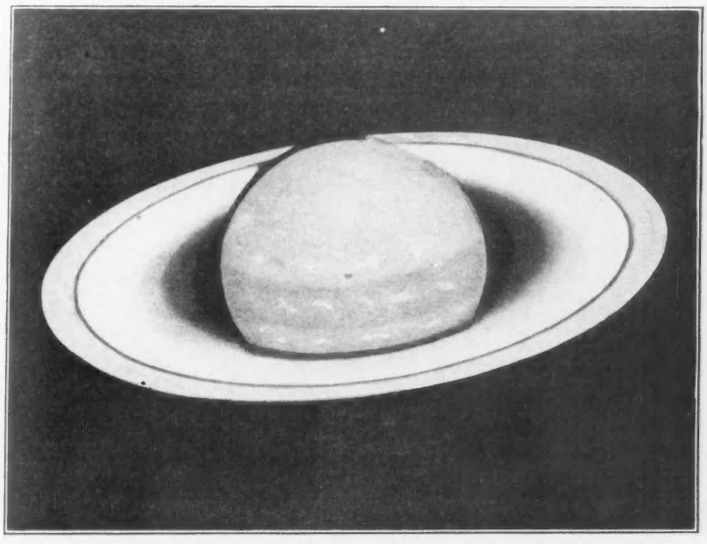
BUREAU OF STANDARDS
APR 14 1923
LIBRARY

THE TECH ENGINEERING NEWS

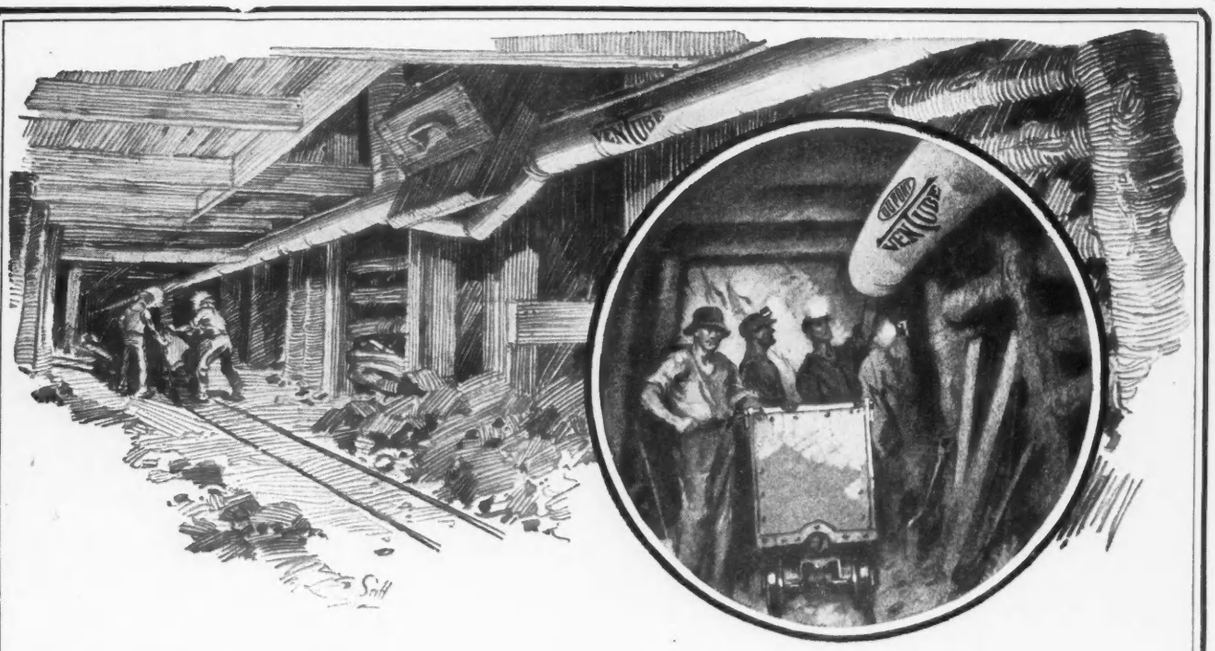
MEMBER OF THE ENGINEERING COLLEGE MAGAZINES ASSOCIATED



SATURN, ONE OF THE OUTER PLANETS

FEBRUARY, 1923

VOL. III MASSACHUSETTS INSTITUTE OF TECHNOLOGY NO. 8



The Result of Long Study of Ventilation Requirements

THE name Du Pont is intimately associated with the mining industry. For over a century we have been developing and perfecting mine explosives—naturally this has led to a thorough study of ventilation requirements.

The result of this study and of our many years of experience in making impervious fabrics, enabled us to perfect an ideal ventilation tubing, VENTUBE, a light, flexible tubing which has a long life under the most difficult underground conditions. VENTUBE stands up—it is waterproof and fungus-proof and highly resistant to all acid, alkaline and gaseous conditions existing in mines.

VENTUBE is easily handled and quickly installed. One man can carry 100 feet on his back and hang 2000 feet in one shift without special tools. VENTUBE quickly exhausts powder gases—provides an adequate supply of fresh air to every miner. Economically, too, for the entire cost of VENTUBE is less than the installation costs alone of a metal system.

Descriptive booklet sent on request.

VENTUBE is supplied in standard lengths of 25, 50 and 100 feet and standard diameters of 8, 12 and 16 inches, with all necessary accessories. Sections equipped with Braley patent ring couplings can be coupled or uncoupled in a few seconds.

E. I. du Pont de Nemours & Co., Inc.
Wilmington, Del.

Branch Offices

Birmingham	Huntington
Boston	New York
Chicago	Pittsburgh
Denver	Scranton
Duluth	Seattle
San Francisco	St. Louis

Canadian Distributors
Canadian Explosives Limited
Montreal, Canada

DU PONT

VENTUBE

© O. E. CO.

The Fisk Building
New York City
CARRÈRE & HASTINGS
Architects

"Designing in Masses"

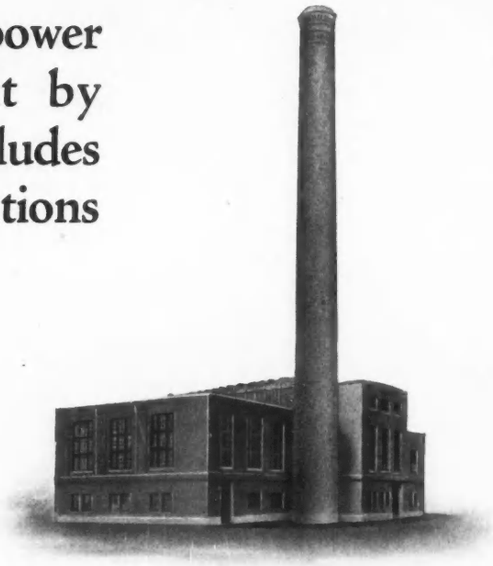
THE new architecture transcends detail and expresses the component solids of the great buildings of today and tomorrow. Gigantic profiles are reared against the sky—true expression of structural facts has now come into its own in architectural design, linking architect and engineer ever more closely together.

Certainly modern invention—modern engineering skill and organization, will prove more than equal to the demands of the architecture of the future.

OTIS ELEVATOR COMPANY
Offices in all Principal Cities of the World

1¼ Million Horse Power

is the capacity of steam power stations designed and built by Stone & Webster. This includes ¼ million horse power in stations now under construction.



BATON ROUGE
1,500 kw.

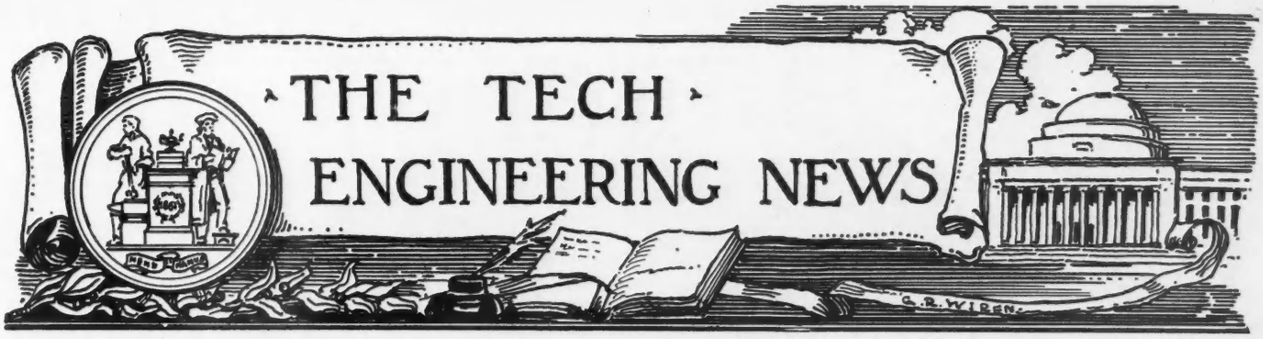
STONE & WEBSTER

INCORPORATED

BOSTON
CHICAGO
SAN FRANCISCO
NEW YORK
PITTSBURGH
PHILADELPHIA

HARTFORD
130,000 kw.

HARTFORD ELECTRIC LIGHT CO.
SOUTH MEADOW STATION



Volume III | CAMBRIDGE, MASS., FEBRUARY, 1923 | Number 8

Copyright 1923 by The Tech Engineering News

Entered as second class matter, June 1, 1920, at the Post Office at Boston, Mass., under the Act of March 3, 1879.
Acceptance for mailing at special rate of postage provided for in Section 1103, Act of October 3, 1917, authorized November 3, 1920.
Published monthly throughout the school year by the undergraduates of the Massachusetts Institute of Technology for the purpose of disseminating news of scientific and industrial interest and of promoting closer coöperation between Alumni and undergraduates. Member of the Engineering College Magazines Associated.

THE MANAGING BOARD

BENJAMIN P. LANE, *Editor-in-Chief*
FORREST G. HARMON, *General Manager*
FRANCIS P. SQUIBB, *Business Manager*
DOUGLAS F. ELLIOTT, *Managing Editor*
THOMAS B. DREW, *Publicity Manager*
ROBERT H. KEAN, *Assistant General Manager*
RODOLPHUS K. TURNER, *Circulation Manager*
WILLIAM F. DONOVAN, JR., *Advertising Manager*

EDITORIAL DEPARTMENT

THE EDITORIAL BOARD

W. F. BURBANK, Assistant Managing Editor
R. A. FORD, News and Statistics Editor
B GASSER, Professional Relations Editor
J. J. PARSONS, Institute Editor
R. L. HERSHEY, Editorials Editor

Publication Division

L. F. SIMONDS, G. J. GROSS, H. D. KINSEY, F. GRANTHAM, F. P. ROMANOFF

Professional Relations Division

R. W. STEWART, A. J. TIGGES, H. HUMPHREY, R. R. SMITH, R. H. MASER

Institute Division

J. R. ROBERTSON

News and Statistics Division

R. R LECLERCQ, B. P. RICHARDSON, JR., J. Y. HOUGHTON, R. F. HAYWARD

Editorials Division

J. O. CRAWFORD, H. W. CULP, H. R. CLARK

BUSINESS DEPARTMENT

THE BUSINESS BOARD

H. G. DONOVAN, Assistant Circulation Manager
C. L. PETZE, JR., Assistant Advertising Manager
C. S. STODTER, Assistant Circulation Manager

Advertising Division

A. COLE, JR., B. E. GROENEWOLD, W. H. MACCALLUM, JR., C. A. HARRISON, R. E. DENSFORD

Circulation Division

S. EMERSON, J. C. CULBERTSON, A. M. SHARP, J. L. CASSIDY

Treasury Division

M. P. O'BRIEN

PUBLICITY DEPARTMENT

O. P. MEAKER, A. L. GUERRERO, J. L. OSTBORG

OTHER MEMBERS OF THE ENGINEERING COLLEGE MAGAZINES ASSOCIATED

The Transit
Iowa Engineer
Colorado Engineer
Nebraska Blue Print
Sibley Journal of Engineering
Rose Technic
Michigan Technic
Minnesota Techno-Log
University of Virginia Journal of Engineering
Ohio State Engineer
Wisconsin Engineer
Illinois Technograph
Cornell Civil Engineer
Kansas State Engineer
Princeton E. A. News Letter

Subscription, per year, $1.75 (To Technology Students $1.50) Single Copy, $.25
Address all communications to The Tech Engineering News, Walker Memorial, Cambridge 39, Massachusetts. Telephone University 6864.
Advertising rates upon application.

TABLE OF CONTENTS

	Page
WHAT IS THE ORIGIN OF THE EARTH? By Prof. William F. Jones, '09	233
THE ENGINEERING LABORATORIES OF THE INSTITUTE. By Prof. Edward F. Miller	234
THE MEASUREMENT OF PERSONALITY AND INTELLIGENCE. By Prof. Henry T. Moore	236
THE MACHINE TOOL LABORATORIES AT TECHNOLOGY. By Prof. Robert H. Smith	237
MECHANICS OF ELASTICITY AND LIMITATIONS OF HOOKE'S LAW. By C. A. P. Turner	238
THE APPLICATION OF COLOR IN INDUSTRY. By Hibbard S. Busby, '14	239
HEATING BUILDINGS BY FUEL OIL. By C. A. Schellens, '10 and A. T. Trowbridge, '06	240
JOHN RIPLEY FREEMAN.	241
THE BALANCING OF ROTATING MASSES. By Major F. Johnstone Taylor	246

Adjustable

Timken adjustability is based upon the sound engineering principle that wherever there is motion there is wear.

The mechanical device—the automotive vehicle—which provides most completely for compensation for unavoidable wear is the more nearly perfect, the more refined.

No matter what type or form of physical characteristics exist, if one part moves upon another part wear must follow.

The great difference between the Timken type of anti-friction bearing and other types—which wear as soon or sooner than Timken Tapered Roller Bearings—is:

That when that wear which *must* follow motion does occur (—after many thousands of miles—) Timken Tapered Roller Bearings may easily and quickly be adjusted to compensate for that wear and made to function as when new. Thus are shafts held in absolute alignment—gears kept in perfect mesh—and quietness made permanent.

More than 68,000,000 Timken Tapered Roller Bearings installed by more than 424 American and European manufacturers bear silent witness to the practicability of this inherent Timken characteristic.

The Timken Roller Bearing Co
CANTON, OHIO

TIMKEN
Tapered
ROLLER BEARINGS

THE TECH ENGINEERING NEWS

THE PROFESSIONAL JOURNAL OF THE ALUMNI AND UNDERGRADUATES OF THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY

VOLUME III FEBRUARY, 1923 NUMBER 8

WHAT IS THE ORIGIN OF THE EARTH?

By Prof. William F. JONES, '09

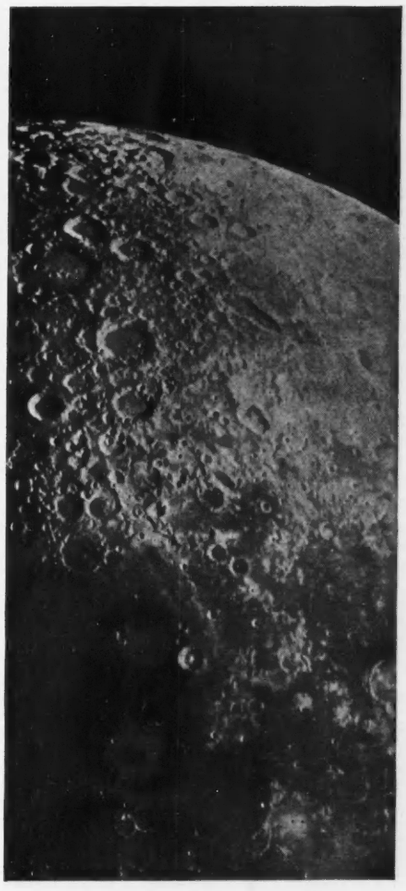
Assistant Professor of Geology, Massachusetts Institute of Technology

The ancient races of the earth saw the supernatural in everything about them. They wove legends and stories around natural phenomena with, of course, an utter disregard for physical laws. But that the question of the origin of the earth was of widespread interest there is made evident from the fact that it became incorporated in all the great religious books of the time. Today some few scientific investigators are trying to fathom the depths of the unknown, but man in general plods his way without thought of the planet over which he plods, from which he sprang, and from which he gains his sustenance.

Whence did the earth come and whither is it going? The ancients were content to look upon the earth as the pivotal center of the universe with the sun and moon and stars as lights in a nearby firmament created solely for their benefit. This was a conceit born of the lack of scientific thought or logic. As time has gone on we have been able to see deeper and deeper into the limitless space around us and the more we see and know the more we come to realize that the earth itself is but an insignificant member of an insignificant family among a great host of bodies in a far grander dynamic scheme.

It is doubtful if we will ever be able to answer categorically the question of the earth's origin, but that does not render our attempts less interesting — it makes them more interesting — but we cannot even formulate an hypothetical answer to the question without enlarging our vision and scope of inquiry to include the earth's sister planets, and the sun, and even the stars in the great beyond. We must array the innumerable facts as to the earth itself, its make-up and dynamic behavior, and the make-up and dynamic behavior of the family of planets and the sun as a whole, and what we know of the evolution of the stars. Any tenable hypothesis must stand in the light of these facts.

That the earth was born of the sun is a logical deduction since the two are composed of the same materials.



A PART OF THE MOON AS SEEN THROUGH A HIGH POWERED TELESCOPE

They are different in physical state, but this is the result of difference in mass and temperature. So we can logically assume that the planets of the solar system were belched forth from the sun in such a way that the material could not return but was thrown into orbital revolution around the parent body. What was the cause of this partial disruption of the sun and the dispersion of the material into a system of revolutionary dynamics? It was not haphazard, for all the planets revolve in the same direction around the sun and their orbital planes are very nearly coincident, and furthermore the planets all rotate on their axes in the same way.

The sun is a storehouse of enormous explosive energy, but this potent explosive energy is held somewhat in restraint by the equally prodigious power of the sun's gravity. In the observed eruptions from the sun material is projected at velocities up to three hundred miles per second to distances of many thousands of miles from the surface. In fact, some eruptions have been observed in which material was sent away from the sun at a velocity above the critical, — three hundred eighty-two miles per second. Almost any one of these eruptions contains enough material to make a planet comparable to the earth, and it must be remembered that the total mass of planetary material in the solar system is only about one seven-hundredth of the mass of the sun. The demands of the case are not then excessive.

For material of the sun then to leave its surface at a velocity sufficient to project it beyond the power of the sun to gather it in again, either the explosive energy must overcome the gravitative control or the gravitative control must be correspondingly reduced. But could increase in explosive energy alone give rise to such a systematic arrangement of orbital revolution and axial rotation as the system exhibits? There must have been some definite lateral force which gave to the dispersed material a slanting motion

(Continued on page 252)

THE ENGINEERING LABORATORIES OF THE INSTITUTE

By Prof. EDWARD F. MILLER

Head of Department of Mechanical Engineering, Massachusetts Institute of Technology

At the time the plans of the new buildings were drawn it was believed that these laboratories, which as a whole, exclusive of corridors and offices, occupy something over seventy thousand square feet of floor space, would afford sufficient room to contain the equipment necessary for instruction, and at the same time offer ample facilities for research, for a total enrollment of four thousand students, on the assumption that the division of the student body between the different courses would remain in the future approximately the same in percentage as in the year 1914.

The rapid growth of the courses in Business Administration, in Chemical Engineering, in Electrical Engineering, and in Mechanical Engineering has made it necessary during the last two years to give instruction to a greater number of students with a total registration of thirty-five hundred than would have been expected with a registration of four thousand with the distribution of numbers between courses as in the year 1914.

The capacity of the laboratories has not yet been reached, however. Sections of sixty men have been assigned, this being the limit which can be taken care of with the present laboratory staff. By increasing the staff, however, greater numbers can be assigned to a section.

Before planning these laboratories, a study was made of the equipment of the leading engineering schools in this country and abroad. After the plans were made they were shown to a number of leading engineers who gave valuable suggestions, as did also some of the professors at Harvard, at Worcester Polytechnic, and at Cornell.

Seven schemes were worked out in detail before the final one was chosen. That it was wise to spend time on these drawings has been evident, as thus far there have been practically no changes made or suggested.

The equipment of the laboratories was selected with a view to giving the student practise in such experimental work as an engineer in the pursuit of his profession is called upon to perform, and to provide ample facilities for original investigation and for research.

The Engineering Laboratories may be divided into the following sections: Steam, Hydraulic, Compressed Air, Refrigeration and Heat Transmission, Gas Engine, Material Testing, including the Heat Treatment Laboratory, Power Measurement Laboratory, and Textile Laboratory.

The material testing section, which occupies sixteen thousand square feet, is divided among three floors and a basement. In the basement is found equipment for work with concrete including a motor-driven mixer. There are also storage bins for sand, rock, and cement, and room for hand mixing. Complete equipment for testing road materials is also to be found here. The first floor contains the heavier testing machines, notable among which are an Amsler Laffon compression machine of one million pounds capacity and an Emery testing machine of three hundred thousand pounds capacity capable of testing a specimen eighteen feet long in compression and twelve feet long in tension. On the second floor are found three testing machines of capacities of one hundred, fifty, and thirty thousand pounds which are equipped with holders for screwed end specimens. Here also are four torsion machines and three machines for testing wire in tension. The third floor has special machines and some reserved for research work.

The Heat Treatment Laboratory contains the regular equipment for making tests for hardness and for machining hardness. The equipment further includes six gas fired furnaces and seven electric furnaces together with some experimental furnaces. These furnaces are of various types adapted to specific uses. There is also an extensive assortment of temperature measurement and control instruments, as well as apparatus for the microscopic examination of materials.

The Hydraulic section, together with some steam equipment which may be classed either as steam or hydraulic, occupies a floor space of about twenty-five thousand square feet. As the hydraulic section is located in the southern end of the laboratory with no chance to enlarge except by moving out some of the steam equipment which is located in the northern end where there is a chance for growth into a new building when one is built, the space originally given to hydraulics was considerably larger than that given to any other section.

The largest piece of apparatus is a complete plant for testing water wheels. Wheels using up to fifty cubic feet per second can be tested under heads of thirty-eight feet. A Worthington centrifugal pump, with thirty-six inch suction, driven by an American Ball angle compound engine of three hundred fifty horse power, cylinders sixteen inches and thirty inches by fifteen inches, draws water from canals in the basement and discharges through a thirty inch Venturi meter into a steel canal five feet wide, five feet deep and one hundred and thirty-five feet long, located on the second floor. This

THE TECHNOLOGY SERIES

Unfortunately, Tech men can never avail themselves of every advantage their Alma Mater has to offer and many alumni, who for a period, have been under her guidance have never seen the new plant and have no way of knowing their Alma Mater's increased sphere of activity. This year, THE TECH ENGINEERING NEWS is making a special effort to ameliorate this situation in presenting this series of articles on the new Technology, its business management, the work carried on in the laboratories, and the plans for the future. This series, of which this article is the fifth, has been prepared by men thoroughly familiar with the phases they treat upon and is as follows:

THE TECHNOLOGY BUILDINGS ..... October
F. J. Whiting, Editor, Stone & Webster Journal.

THE GROUNDS AND THEIR DEVELOPMENT ..... November
H. J. Carlson, President Alumni Association.

THE BUSINESS ADMINISTRATION OF THE INSTITUTE ..... December
H. S. Ford, Bursar.

THE POWER SYSTEM OF THE INSTITUTE ..... January
A. S. Smith, Superintendent of Buildings and Power.

THE ENGINEERING LABORATORIES ..... February
Prof. E. F. Miller, Head of Department of Mechanical Engineering.

THE MACHINE TOOL LABORATORIES ..... February
Prof. R. H. Smith, Assistant Professor in Machine Construction.

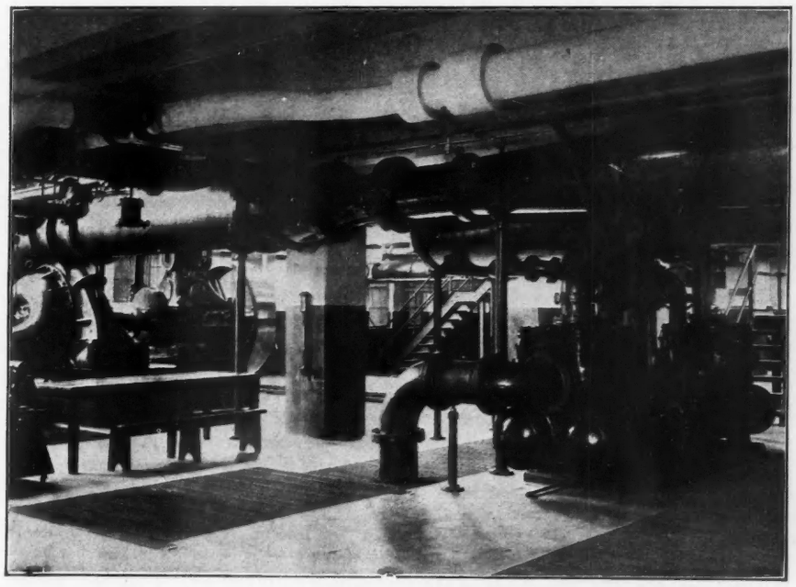
THE MINING AND GEOLOGICAL LABORATORIES ..... March
Prof. C. E. Locke, Associate Professor of Mining Engineering.

THE ELECTRICAL ENGINEERING LABORATORIES ..... March
Prof. F. A. Laws, Professor of Electrical Measurements.

THE CHEMICAL AND PHYSICAL LABORATORIES ..... April
Prof. H. P. Talbot, Dean, Former Head of Department of Chemistry.

RESEARCH AT THE INSTITUTE ..... May
Prof. H. M. Goodwin, Professor of Electrochemistry.

PLANS FOR THE FUTURE ..... June
To be announced.



VIEW IN BASEMENT OF STEAM AND HYDRAULIC LABORATORY

The grating covers a portion of the extensive system of canals in the laboratory.

steel canal discharges into a penstock twelve feet in diameter supported on I-beams spanning a tail race ten feet wide and ninety feet long, the bottom of this tail race being about two feet below the basement floor.

The water wheel to be tested is submerged in the penstock and attached to a casting bolted to the steel plate which forms the bottom of the penstock; this plate resting on the I-beams which span this end of the tail race. A draft tube is attached to the bottom of this same casting.

The back end of the tail race is built up sixteen feet above the floor. A main hydraulic gate ten feet wide and ten feet deep, provided with grid openings controlled by a second grid gate sliding on the main gate may be operated from the first floor, so that any level desired in the pit under the draft tube may be held and thus the effective length of the draft tube varied. This gate with grid-gate weighs ten tons, its bearing surface being composition covered, to prevent corrosion.

Water after passing the main gate flows over a submerged weir and finally over a standard crest ten feet wide.

In order to test weirs of moderate size and to measure with accuracy quantities of water under one thousand cubic feet per minute a trough three feet square and one hundred feet in length has been constructed to discharge into four large tanks, two ten feet in diameter and ten feet tall and two six feet in diameter and ten feet tall, supplied with gage glasses for measuring levels. These tanks are filled and discharged alternately through large valves operated by hydraulic cylinders.

Water under static heads up to five hundred feet is obtained in quantities up to fifteen hundred gallons per minute by pumping water into, and compressing the air in, a closed cylinder five feet in diameter, thirty feet tall, made of seven-eighths inch steel plate. Two impulse water wheels, one of thirty horse power and one of twenty horse power are supplied with water from this closed cylinder.

Water under pressures up to two hundred and fifty pounds is supplied by either a steam driven, outside packed, Warren pot valve pump of a capacity of fifteen hundred gallons per minute, or by a one hundred horse power Terry turbine driving a four-stage Janesville centrifugal, or by a rotary pump of large size. Water under pressures up to one hundred and fifty pounds is supplied by a sixteen inch by ten and one-half inch duplex pump, by a one hundred and fifty horse power De Laval turbine with two-stage centrifugal, by a Gould or a Davis triplex pump, by a large Emerson pump, and by two pulsometers.

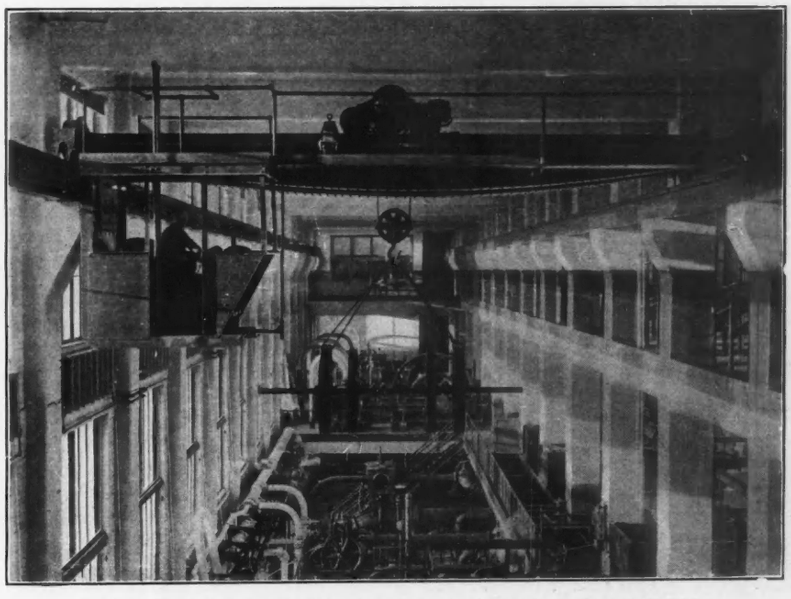
In order to test reciprocating pumps with actual suction lifts, two wells each ten feet long and five feet wide extend twenty-six feet below the basement floor; water being supplied from a canal system to these wells by sixteen-inch valves operated from the floor; the level is maintained by the amount of opening given these valves which have been designed in the form of a cone having a very small taper so that accurate regulation is possible.

A raised platform about fifteen feet by fifteen feet has been built up over these deep wells. This platform, which is about forty-two feet above the bottom of the well and sixteen feet about the basement floor, serves as the operating platform for a Luitweiler deep well pump, for a four-inch Pohle Air Lift pump, for a Weber subterranean pump, for an Emerson steam pump and for a pulsometer.

A Rife hydraulic ram with four-inch drive pipe and a Gould double ram with two three-inch drive pipes have been installed on the second floor; the water discharged and the overflow is weighed in the basement.

The Steam section occupies about

(Continued on page 264)



CRANE BAY IN MECHANICAL ENGINEERING LABORATORY

THE MEASUREMENT OF PERSONALITY AND INTELLIGENCE

By Prof. HENRY T. MOORE
Professor of Psychology at Dartmouth College

The development of psychological tests is practically a thing of the last twenty years, but during that time they have multiplied with an almost appalling rapidity. Testmaking has become the favorite indoor sport of psychologists large and small, and of many who are not psychologists at all, and the result has been that the term mental test has come to mean vaguely anything from a picture puzzle in a Sunday newspaper to a grilling three-hour examination such as is now being given at Columbia University as one of the methods of meeting entrance requirements. Obviously only a small part of such material could have any real worth, and the somewhat skeptical attitude of the general public to the movement was in a considerable measure justified by the extravagant claims of many of the testmakers. But out of the many bushels of chaff there have emerged some very valuable grains of wheat. It has been mathematically demonstrated on the basis of twenty years experimenting that certain short tests do show a surprising correspondence with what we ordinarily know as general intelligence. It was by combining eight such tests into one examination known as Army Alpha that the Division of Psychology was able to make good its claim to being able to classify recruits fairly accurately with regard to their ability to think quickly and to understand directions. The practical success of the Alpha examination and the fact that it was applied according to a standard method to more than 1,500,000 men has stimulated a wide interest in the possible applications of all forms of psychological tests to education and industry.

The keynote of all psychological testing is, as Thorndike has well said, "simply the assumption that whatever exists exists in some amount." It is the ambition of present day psychology to express quantitatively those human traits having to do with intelligence and personality. A brief description of the kind of work that has been done in each of these fields will perhaps serve as a basis for the critical appreciation of the test movement in psychology.

We may begin with the measurements having to do with intelligence. It is perhaps unfortunate that the group examinations of the sort that were given in the army, and later in a large number of colleges and to some extent in industry, have gone by the name "intelligence tests." This name suggests that intelligence is something simple and capable of definite formulation once for all. It also suggests that intelligence may be expected to vary directly with a man's score on the test. Both of these assumptions are false. It is quite possible that of two men, both of whom stood in the highest ten per cent of a so-called intelligence test, one might be the president of a railroad, and the other merely a champion checker player in a country grocery store. It is certain that a Helmholtz or a Leibnitz would rank well up in our intelligence tests. But it is highly probable that they would not score as high as some of the brightest college freshmen. It is quite conceivable that a prosperous farmer of less than grammar school education might fare as badly in his score as would a city bred moron. It is evident, therefore, that such measurements are not to be taken as a direct quantitative expression of intelligence, but of some mental characteristics that have a high degree of correlation with intelligence for ordinary purposes. The newer term "mental alertness tests" is altogether to be preferred in describing the standard psychological group examinations.

Even the mental alertness in question is concerned almost wholly with the quick manipulation of language and number concepts. No especial account is taken of mechanical, social, or administrative thinking. The "intelligence test," when stripped for racing, is seen to be merely a something that will score mental alertness in the manipulation of language and number relations. But having made these admissions, we shall next see, I believe, that such tests do have an important relation with intelligence, so important a relation that it would be foolish to leave them out of account in any statistical treatment of situations involving intelligence.

As an example of the availability and usefulness of the mental alertness test I may take the Completion of Definitions Test, which has given excellent results at Dartmouth College. The test consists of forty sentences in which one or more missing words are to be supplied to complete a definition. Three samples of the forty sentences are the following:

1. A . . . is any body, except a comet, that . . . about the sun.

2. A . . . is a strip of metal inserted for safety in an . . . circuit.

3. An . . . is an error in the order of time, especially one by which an event is placed too early.

The seventy-five completions require a fairly wide range of information and a rigorously logical type of association. The test takes fifteen minutes to give, costs about a cent a man, and can be scored with accuracy by any large class in elementary psychology.

The best score in a freshman class of 575 was 70 points out of a possible 75. The poorest score, was eleven points. At the end of the first semester the best man had a college record of five A grades; the poorest man left college with a record of five E grades. Of the men in the lowest twenty per cent of the test scores one third were either separated from college or on probation. Of the men in the highest twenty per cent only one fortieth had met with similar misfortune. The correspondence between test proficiency and scholarship indicated that the academic chances of the men rated A on the test were ten times as good as those of the men rated E. An interesting sidelight on the value of such a test in indicating the probable academic success of a man is to be seen in the fact that the average grade of thirty-eight members of the Technology faculty was sixty-two points, whereas the average of college freshmen was only thirty-seven points.

It is not yet feasible to give such tests as part of the entrance requirement of most colleges, as has been done so successfully at Columbia. But with the rapidly increasing high school use of the National Intelligence Tests, and with the further standardization of group test methods by the National Research Council, it is only a question of a few years until every high and preparatory school will be provided with the facilities for certifying a student as to his score on a nationally standardized mental alertness test. The present uses of the psychological group examination for freshmen at Dartmouth came about mainly through the work of the Dean of Freshmen and the Associate Dean, who is in effect the personnel officer of the college. The test scores give to these officers the means of knowing with some assurance the extent to which a man's performance in college corresponds with what may be reasonably expected of

(*Continued on page 262*)

THE MACHINE TOOL LABORATORIES AT TECHNOLOGY

By Prof. ROBERT H. SMITH

Assistant Professor of Machine Construction, Massachusetts Institute of Technology

William Barton Rogers came to Massachusetts from Virginia with the purpose of establishing an engineering school. The plan of his school he asserted to be, "To teach young men by making them do things." As each subject contained many important principles, it was found best to teach the subjects by organized courses of principles or problems, now called the laboratory method.

For many years the Massachusetts Institute of Technology has taught machine work successfully to large classes of engineering students by the laboratory method.

These courses give a broad training because they teach the basic principles which are applied in the problems of modern manufacturing and are helpful in solving engineering problems, designing machinery, managing manufacturing plants, and in directing industrial activities.

The variety of work covered and the information and skill that a student may acquire in these intensive courses may be obtained by a number of years of work in a machine shop, but he will be a long time learning, since experience is a slow teacher.

Eight of the different professional courses and a group of United States Army Ordnance Officers include machine work in their curriculum. These courses range from sixty to one hundred and sixty hours.

Systematic courses of instruction are given in the use of both hand and machine tools, through groups of processes and problems.

The hand problems are planned especially to teach filing, scraping, electric and oxy-acetylene welding, drilling, and pipe fitting.

The machine-tool problems are designed to give training in the use of standard machine tools — such as lathe work, planing, milling, and on production machines, such as gear cutting machines, turret lathes, and automatic screw machines.

Experience has proven that intensive courses give the best results. Courses planned to teach principles, are not only highly instructive, but are practical and time savers. They not only touch the high places, but they are broad and at the same time are not extravagant time wasters on non-essentials. Systematic methods and organization produce efficiency without confusion. If a young man is taught systematically by modern methods, his career will be progressive.

Textbooks are used, which furnish the problems and courses. They give detailed information, drawings, and schedules of operations with the time required for each problem.

The use of textbooks has doubled the efficiency of the courses by furnishing the instructions and information which the students need to enable them to do accurate work by correct methods from the beginning.

During the past few years the number of students taking machine work at the Institute has increased about three-fold. To meet this large increase in numbers, the machine tool laboratory and its equipment has been more than doubled. This large variety of machine tools is in itself an important educational factor.

General instruction is given by lectures and demonstrations in the lecture room, preceding the students' work in the laboratory. This general instruction is supplemented by individual instruction in the laboratory. Records of the students' work are made at the completion of each individual problem.

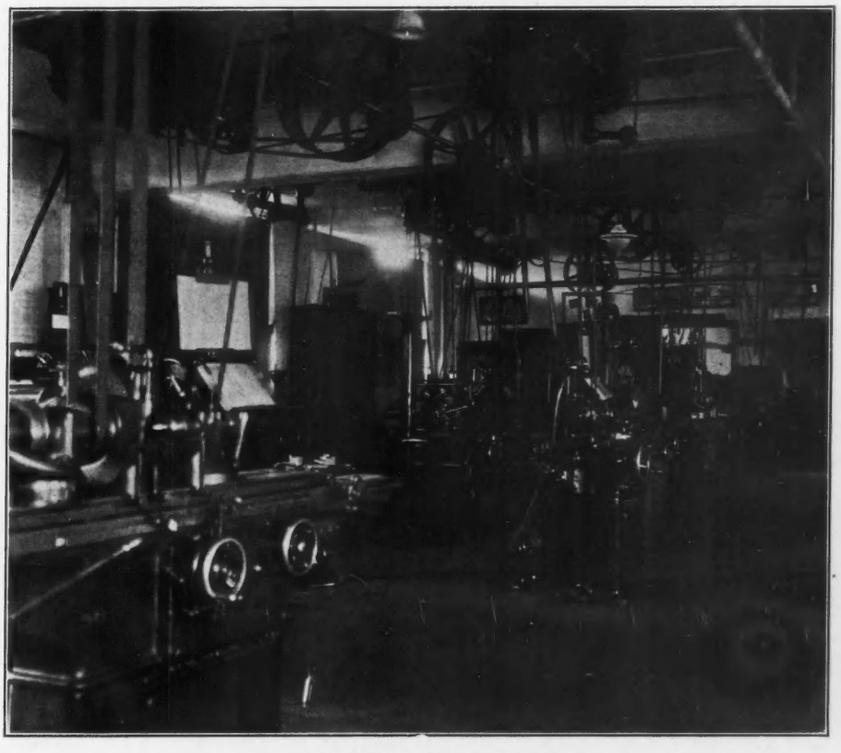
A teaching unit generally consists of instructors, equipment, and a course of some kind. It has been said that a chain is only as strong as its weakest link. There are many good teachers. A good equipment is obtainable. The weakest link is often the lack of a systematic course.

By the laboratory method, students are given complete instruction before they begin the work; each student is furnished with a complete equipment for the work he is to do; and no time is wasted in rediscovering elementary facts.

In the lecture room, the instructor presupposes the ignorance of his students in this subject; and he begins his instruction at the very foundation, thus developing the mechanical judgment of the students by making, in advance of practice, a careful study of the problems and their solution.

The laboratory method creates enthusiasm and class spirit which are large factors in acquiring information and skill. It also trains students to think logically and to plan intelligently. The elementary and advanced principles are so thoroughly taught by

(*Continued on page 250*)



VIEW OF GRINDING MACHINES

The student is taught the theory and practice of using these modern machines.

MECHANICS OF ELASTICITY AND LIMITATIONS OF HOOKE'S LAW

By C. A. P. TURNER

C. A. P. Turner Company, Consulting Engineers, Minneapolis, Minnesota

The early elasticians regarded a homogeneous isotropic body as one which presented the same resistance to stress in all directions and in which by the very definition the resistance to shear, tension, and compression was the same, and there was therefore but one coefficient of elasticity which could apply to such a body.

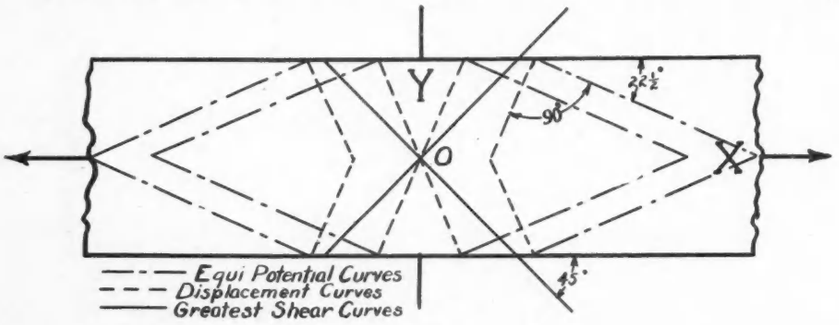
All present day books on elasticity and mechanics of materials, present the astonishing proposition that the potential energy of strain is measured by the work of deformation and is equal thereto.

This proposition is inharmonious with the thermo dynamic theory since the effect of strain upon the intrinsic heat or vibratory energy of the molecules or particles of any body is determined by the final state of strain and is independent of the states of strain through which the body passes to reach the final state. Conversely, the work of deformation is dependent, not upon the final state of strain, but upon the intermediate states through which the body has passed to arrive at the final state.

The thermo dynamic theory of elastic displacement, accordingly gives rise to two different moduli called by Kelvin the kinetic modulus representing the instantaneous effect of the strain and a static modulus as the final effect after the temperature change produced by the applied force has disappeared by radiation or conduction.

The mechanical energy in heat units of work by which the state of kinetic internal energy of the bar of steel is changed by stretching it computed in accordance with the formula demonstrated by Kelvin in 1855* is about one and three fourths times the work of deformation figured in terms of the force times half the elongation. If the force is kept statically applied a few minutes change in temperature produced by the application of the load or force disappears in accordance with Newton's law of cooling and we have the phenomena mistakenly called the lag of stress in works on mechanics of materials.

If a beam or spring is bent downward and the load suddenly removed, the vibrations die down far more rapidly than resistance of the air and friction therewith is capable of account for. An unwarranted speculation to account for this is that rapid dying out vibration of the spring is is caused by a mysterious kind of viscosity of the material which deports itself otherwise than in a perfectly elastic manner. The rapidity of dying out of such vibration is readily accounted for by the fact that the potential energy of strain is approximately twice as great as the work of deformation from which the decrease in amplitude may be readily computed. The manner in which this relation can be proved geometrically will now be considered.



STEEL BAR UNDER TENSILE STRESS

As we stretch a steel bar, its length is increased but its width and thickness are automatically decreased an amount accounted for by the so-called Poisson's ratio. The resultant displacement of the particles in the bar about the center line accordingly makes an angle whose tangent to the axis of the bar is the coefficient K or Poisson's ratio. The curves of equi-potential in each octant about the center of the bar of which the axis of the bar and the normal are the planes of division, are orthogonal to the curves of displacement and the elongation along the curves of displacement is twice as great as the contraction along the curves of equi-potential. Since the result of displacement of the particle is affected equally by shear and stretch, the angle of these curves will bisect the angle of greatest shear and the principal strain. That is, as the plane of greatest shear is shown by mechanics to be 45° to the axis of the bar, the curve of displacement will make an angle of 22½° to the bar and the curves of equi-potential will make an angle of 90° to the curve of displacement of 22½° to the normal, if the material be perfectly isotropic.

This amounts to a statement that the elongation along the curve of displacement is twice as great as the contraction along the equi-potential curves, both curves in this case being straight lines. Moreover, the stress in each of the four quadrants in the direction of the displacement is twice as great as the contraction along the curve of equi-potential and because the plane of action of the contraction is twice as great as the plane of action of stretching, compression and tension play equal parts in the resistance to elongation of a bar of isotropic material.

This relation leads immediately to the conclusion that in isotropic material *volume is a kinetic invarient of elastic strain* and that the value of Poisson's ratio for isotropic material is the tangent of 22° 30′ or .4142+ and not .5 as many writers have erroneously supposed from the geometry of displacement and contraction along the curves of displacement and equi-potential respectively. The latter relation is half instead of the coefficient stated.

In the process of rolling, material is squeezed and a state of residual strain results. This comes about by stretching the material along the curves of displacement beyond the limits of elasticity without over-straining it along the curves of equi-potential. Consequently, the greatest effect upon the coefficient in the equilibrium of such overstrain is a reduction for isotropic material to the limit of the tangent of 16° 53½′ which is a little greater than .3.

The annealing effect in cooling tends to increase this to a little more than one third, as the .3 ordinarily determined by experiment does not allow for the effect of restraint of the grips of the machine at the ends of the bar.

The state of residual strain is more of the nature of a right shearing stress.

(*Continued on page 254*)

*See Elasticity, Ency. Brit.

THE APPLICATION OF COLOR IN INDUSTRY

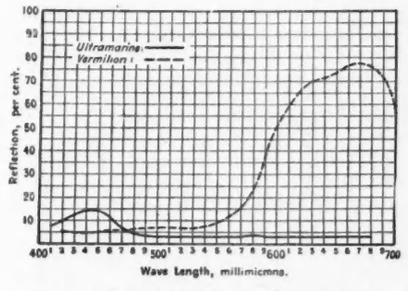
By HIBBARD S. BUSHBY, '14

Research Colorist, Cheney Brothers, South Manchester, Connecticut

Photograph of Apparatus by courtesy of William Goertner, Chicago, Illinois

The use and application of color and the laws which govern its selection represent one more extension of the theoretical investigations of pure science to needs industrial and aesthetic. Its widespread growth during the last seven years is further proof of the growing importance of the place which the physical sciences have filled, compared to the chemical and mechanical. Indeed, the explanation of many complex chemical phenomena becomes the function of the physicist, and to his aid he summons all the intricacies of mechanical skill which long continuous evolution in the shops and laboratories of an industrial nation have developed.

The textile worker encounters problems involving color, or other visual appearances, in 100 per cent of his



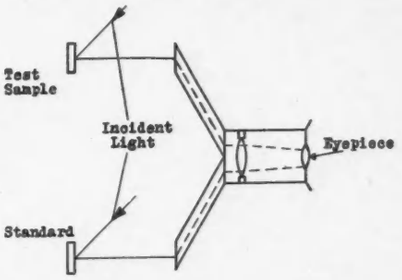
Curves of spectral reflection from analysis made of two pigments by spectrophotometric method.

successive processes. This is obvious in such fabrics as colored prints and jacquard patterns — it may require thoughtful inspection of the problem to appreciate that such materials as black goods, white goods, repeatedly produced coarse goods of the general class of denims, etc., also involve a color problem. It is merely necessary to realize that any fabric is judged for quality by its appearance, — and the dependence upon color importance is inescapable. The clarity of white obtained in white goods is a mark of its quality (and selling price), — the "tone" (or freedom from "rustiness") denotes the quality or "richness" of a black, — the smoothness of color produced on even such a material as a tinted covert cloth draws the attention of the inspecting eye from fibre and weaving defects and adds saleability to a fabric that otherwise draws the maximum of critical attention to its structural qualities.

Specifically, a textile color problem that is handled by the approved methods of laboratory control and analysis requires all the elements of organization, technical skill and economic balance that any broad industrial color problem encounters,—the difference, if any, that exists between these is in the details of routine, degrees of precision, and specialized apparatus required to completely fit the particular problem (and even more, the peculiarities of form and tradition) associated with the industry thus served. For that reason a general outline may be established which is fundamental for all color standardization and development, and the particular needs of the industry left to the skill of the technical advisor charged with the responsibility of obtaining results. That this is fundamentally and perpetually the case is evidenced by the success already attained of the methods mentioned, in paint, paper, varnish, textile, printing, leather, advertising, ceramic, wall paper, decorative, metallurgical, vitreous, and the commission handling establishments.

The subject of the organization and layout of a physical control and research project is so fascinating and of such vital importance to the success of any results to be obtained therefrom as to be worthy of an entirely separate paper, but an article of the brevity of this one must be confined to a survey of the immediate problems of the job itself.

Problems in color divide themselves into three chief lines of which by far the major portion in manufacturing have to do with the routine analysis of samples. This is for the purpose of checking up on quality of production, *i.e.*, verifying that the product constantly maintains its established standard. It frequently happens that this routine analysis also includes the examination of a sample from each lot of raw material purchased for conversion, in order to verify that such material meets existing specifications. Where the material to be thus examined is free to have an allowable color and finish difference or "tolerance," it is usually the case that very simple apparatus is sufficient to make the test, indeed no actual measurement is necessary, simply a comparison of the test samples with the recognized standard. An idea of the simplicity of equipment required for some of this work may be gained from the diagram below, which pictures a common means

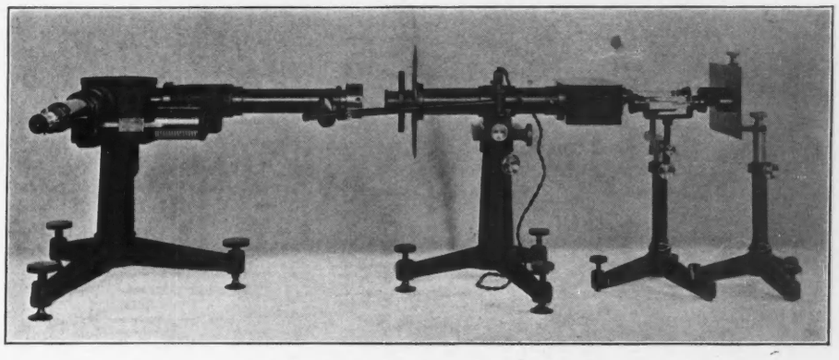


of comparing (without measurement) an unknown sample and the standard for that class.

More specific rating of materials, liquid, solid, or plastic may be accomplished by means of more refined instruments than that sketched above and the degree of this refinement of analysis extends all the way from simple comparometers through accurate photometers for the measurement of individual special color qualities up to the spectrophotometers which provide for graphical records, expressive of the appearance and composition of a color.

The second demand made upon the

(*Continued on page 258*)



NUTTING SPECTROPHOTOMETER

The absorption spectra of colored solutions is obtained from this apparatus and used in plotting graphical records.

HEATING BUILDINGS BY FUEL OIL

By C. A. SCHELLENS, '10, and A. T. TROWBRIDGE, '06
Simplex Oil Heating Company, Boston

Fuel oil is now playing an important part in heating buildings in the larger cities where an oil supply is available. It is cheaper than coal; there are no ashes; and the fires require a minimum of attention. It is, moreover, cleaner and more convenient to handle. The

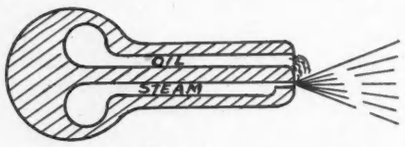


FIGURE 1. Steam Jet Burner.

supply of oil is at present very dependable as it is not affected by strikes, and this condition promises to continue, as the item of labor entering into its production and distribution is relatively very small. There are at present in Boston no less than two hundred buildings which are heated by heavy fuel oil, and a majority of the larger office buildings, apartment houses, and garages now under construction are installing this system.

Oil heating is, of course, restricted to those localities where an oil supply is available. Deliveries of heavy fuel oil are at present only procurable in our larger cities. These are by tank trucks of about 1,500 gallons capacity, necessitating a large storage tank, usually of not less than 2,500 gallons capacity, for each installation. Lighter fuel oils and kerosene are more generally obtainable and in smaller quantities, but the greater cost of these oils restricts their use to smaller buildings and homes where convenience rather than low fuel cost is desired. Heavy fuel oil is at present selling at from 4.25 to 5.25 cents per gallon delivered in Boston. Light fuel oil is procurable at about nine cents per gallon delivered.

Storage tanks may be located in the basement or under ground outside as close to the boiler as possible. They are constructed of steel or reinforced concrete, made oil proof by a suitable coating on the inside. In the case of heavy oil installations the fire protection laws are very rigid because of the large volume of oil stored. In Massachusetts the tanks must be either buried two feet under the surface of the ground, or must be placed in a concrete or brick enclosure with sand fill between tanks and enclosing walls and above the tank. The boiler must be in a fireproof boiler room. The cost of the installation is therefore considerable, particularly in the case of old buildings whose basements are not fireproof. The light oil installations are much lower in cost because of the smaller oil storage and the less rigorous fire regulations.

In devising apparatus to burn the heavier oils it seems that the simplest and most apparent method, that of gasifying the oil by heat, must be rejected. When oils heavier than comercial kerosene are heated to the vaporization point at atmospheric pressure, chemical as well as physical changes take place. The oil is "cracked," *i.e.*, partially broken up into lighter constituents, and this change is accompanied by the formation of solid carbon which tends to clog the orifices from which the gas issues. We are familiar with the plumber's torch which burns satisfactorily with gasolene as fuel, but which gives trouble due to clogging when the heavier kerosenes are used. For the same reason it does not seem practical to burn the heavier oils in open pans, dripping over brick work, etc., as carbon separates out of the liquid, forming large cinders which burn with great reluctance.

It is now recognized that the proper principles for burning heavy oils are, first, breaking up the oil into small droplets of liquid in the form of a jet

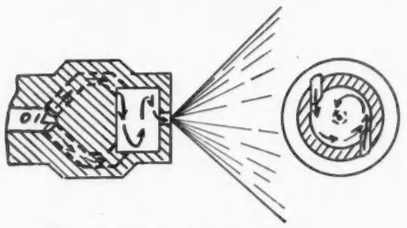


FIGURE 2. Mechanical Burner.

and second, thoroughly mixing these droplets with the proper amount of air for combustion.

When the jet is burning a nucleus of carbon will be formed in each droplet and it is therefore necessary to provide combustion space such that all nuclei are burned completely before they strike any furnace walls or heating surface. The flame is yellowish white as compared with the blue flame of the plumber's torch. This is due to incandescent particles of carbon. If these particles strike the relatively cold heating surface of the boiler before being consumed, they tend to form a carbon deposit. If they strike hot firebrick they may or may not build up a cinder depending on the access of combustion air to the deposit. Firebrick lining tends to aid combustion as it raises the temperature of the furnace.

Present day commercial oil burners fall into three classes. First, burners in which oil is atomised by a jet of steam or compressed air. Second, so-called mechanical burners. Oil is forced at high pressure through small tangential orifices leading into a vortex chamber, and through a small hole in the center of the chamber. It attains at this central hole a high spinning

(*Continued on page 256*)

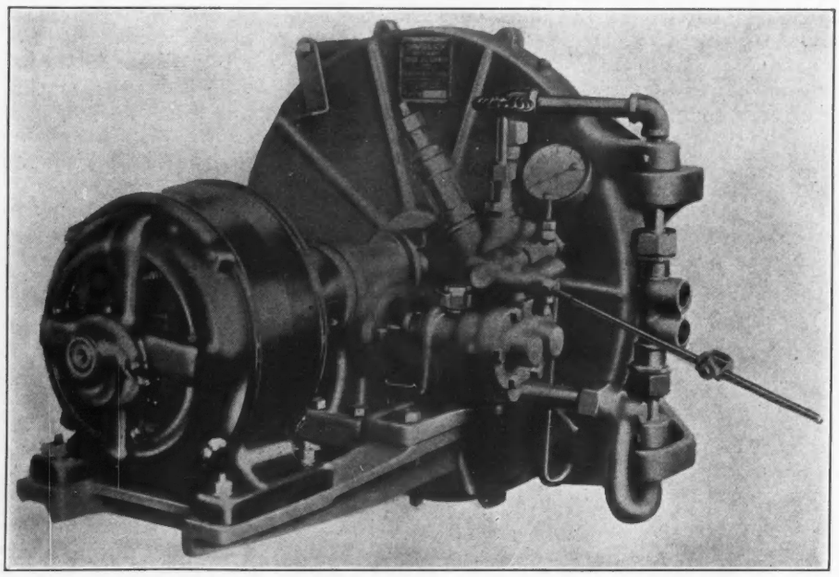


FIGURE 4. EXTERIOR OF ROTARY CRUDE OIL BURNER
The mounting of the motor so that it can drive both the blower and the gear pump is clearly shown.

JOHN RIPLEY FREEMAN

The task of writing a biography about John R. Freeman, '76, is a pleasant one indeed because it concerns a very live man whose work affords hope, inspiration and romance for the student, — and particularly for men of this Institute, among the graduates of which he is one of the most eminent.

Freeman was born in West Bridgeton, Maine, July 27, 1855, where his early days were spent on a farm; his education was begun in the district school of that place and was supplemented by study in the public schools of Portland, Maine, and Lawrence, Massachusetts. In 1872 he entered Technology at a time when the number of students was less than one-tenth of the present, when the meagerness of the laboratory equipment was made good by the enthusiasm and ingenuity of the professors, with whom the student fortunately had intimate contact. The advantages of dormitories or college activities were lacking, but even then the standards of intellectual attainment were high.

As a student Freeman showed distinct capacity and a very acquisitive mind. He was intensely interested in the problems before him. Outside of the classroom he turned his time to good account. He was interested in a broad range of subjects and always ready to lend a hand. He drove himself hard in his work and he played with equal zest. His financial resources were limited. He had saved up enough to cover one or two years of schooling and when, about at the end of his resources, he went in to explain to the President, — who was more accessible in those early days of fewer students, — that he would be back after a year of work, he was surprised and delighted to learn that his note would be accepted in lieu of the cash fee, and he was thus able to continue without interrupting his course. That the wolf was never far from his door, as a student, is evidenced by a classmate's story that he laughed off the absence of an overcoat with the comment that he was toughening himself.

During his summers, both in high school and at college, he was employed in various engineering capacities by the Essex (water power) Company of Lawrence, and after graduation from the civil engineering course, in 1876, he re-entered the employ of the company and soon rose from the position of Junior to that of Principal Assistant Engineer. He was deeply interested in his work and in his progress in it, often going to the office in the evening to plan his job for the next day, so as to make it move faster during working hours. During the ten-year period which followed he came into close contact with several of the foremost hydraulic engineers of that time, — Hiram F. Mills, James B. Francis and Charles S. Storrow, — all of whom are now dead. Under the direction of Mills and Francis he spent many months, perhaps years, in scientific investigation and laboratory experiments on many matters connected with the flow of water and in measuring the supply of water power to the factories at Lawrence and Lowell, Massachusetts, and Manchester, New Hampshire. From 1876 to 1886 he was in charge of many of Mills' experiments in hydraulics. One of his assistants of that day says of him:

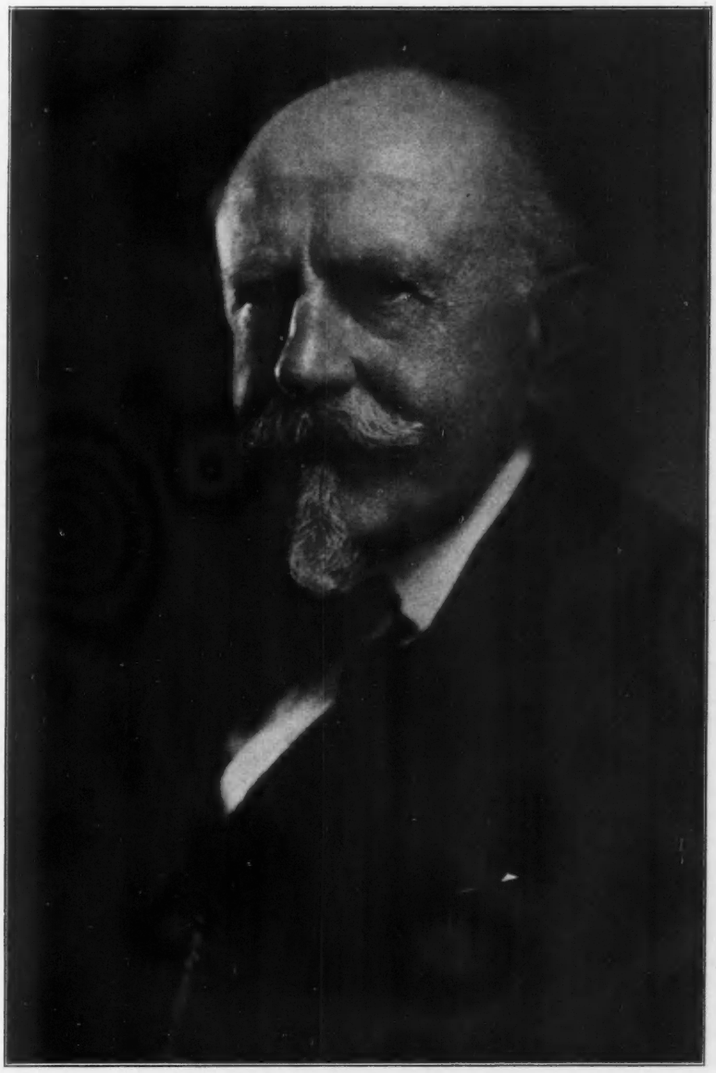
"I remember well his eagerness to have young fellows like myself get an insight into the real worth of the experiments and something besides pay out of the work."

Here among his associates were numbered the well-known hydraulic engineers, Loammi F. Baldwin, '74; George F. Swain, '77; Arthur T. Safford; Joseph P. Gray, '77; Richard A. Hale, '77; and J. Waldo Smith, '87.

Under Mills he had charge of important improvements in the water power of Bellows Falls Vermont, and made the preliminary investigations, surveys and designs for the Sewalls Falls water power works located just above Concord, New Hampshire.

In 1886 he was offered a position with the Associated Factory Mutual Fire Insurance Companies of Boston, which would take him into many of the leading industrial works. In those days the engineer did not play the active part, which he has since in insurance. Being in doubt as to whether the proffered position would lead him too far astray from his chosen profession of hydraulic engineering, he

(*Continued on page 248*)



JOHN RIPLEY FREEMAN

MONTHLY NEWS

A New Solid Fuel: Metaldehyde. Recently a new fuel has been put out on the market that is of both commercial and chemical interest. There are many types of solid fuels on the market which use as their heat producing medium alcohol dissolved in a non-volatile solvent. Such solvents as agar-agar, collodion and cellulose acetate have been used with some success. However, due to the volatility of the alcohol, these fuels must be kept in air-tight vessels.

A Swiss concern, the "Usines Electriques of Basel" seems to have solved the problem. The new fuel metaldehyde is a polymer of acetaldehyde which is made through a synthetic process from calcium carbide. It is made by cooling acetaldehyde to a low temperature and then adding dilute sulphuric acid. Metaldehyde crystallizes out and can be separated by filtration. Metaldehyde does not melt under atmospheric pressure. It starts to sublime between 112 and 115 degrees C. and is decomposed by heat into acetaldehyde under which form it burns. The fuel itself is kept so cool that it is possible to extinguish the flame with the palm of the hand.

— *Towne Scientific Journal.*

The N. A. C. A. Compressed Air Wind Tunnel. The National Advisory Committee for Aeronautics has completed its new compressed air wind tunnel. Its main characteristics are as follows: A five-foot diameter wind tunnel of the usual type, enclosed within a steel tank fifteen feet in diameter by thirty-four feet in length. The cylinder can sustain an internal pressure of four hundred and fifty pounds per square inch, though for all practical purposes the usual pressure will be around three hundred pounds. The usual appliances are used for lighting recording instruments for the model placed in the test chamber.

Provision is made for setting wing angles from without the cylinder. The air is compressed by two three hundred horse power compound compressors, into a receiving chamber at a one hundred and fifteen pound pressure per square inch. Then it is again compressed by a one hundred and seventy-five horse power duplex booster compressor to the desired three hundred pounds in the test chamber. The wind tunnel motor is a three hundred horse power and the Reynolds number is controlled by changing the air density rather than changing the air speed. Provision has been made to avoid opening the chamber until the model is completely tested.

The utility of the old type wind tunnel was limited by the fact that owing to a "scale effect" the results on tests on small models were not immediately applicable to a full sized machine.

To obtain results strictly proportional to those obtained in free flight, the pressure had to be increased to about twenty atmospheres or more to compensate for the difference in the "scale" or Reynolds number for the model and for the full-sized airplane.

This remarkable device was designed by Dr. Max Munk, technical assistant to the National Advisory Committee for Aeronautics.

Traffic Tests at Arlington. Traffic has been started on the circular track of the Bureau of Public Roads of the United States Department of Agriculture, at the Arlington Experimental Station, in the experiment to determine the cause of waving in bituminous surfaces. The track is composed of twenty-seven sections of asphaltic concrete of different mixtures.

Before starting the traffic, profile measurements of the surface were taken with the autographic profile device especially devised for the purpose. Measurements were taken at frequent intervals and will be repeated from time to time as the tests progress in order to determine the rate of formation of inequalities in the surface.

It is also planned to study the flow of the bituminous concrete under traffic. This will be done by noting the movement of brass plugs placed in the surface both in the upper and lower portions.

At present traffic is being confined to a path two and one-half feet wider than the distance between outside edge of tires in order to obtain an accelerated test. This will also leave a space on the track for investigation under summer temperatures.

The wear test on the circular track consisting of sixty-one sections of concrete and located at the outside edge of the bituminous track has also been commenced. In this test concrete made of a great many different materials and mixes are being subjected to a traffic of two solid rubber tired wheels loaded with six hundred pounds per inch of width of tire or approximately that of a five ton truck and traveling at a speed of twenty miles per hour. The device used will be guided by wheels traveling on rails and is electrically driven, the power being transmitted to one of the wheels used to represent the traffic which will make this wheel act as the drive wheel of a truck.

On both the bituminous and the concrete wear test, traffic will run continually during working hours, but from the nature of tests thousands of trips and a considerable period of time will be necessary before much data is secured.

Pilotless Plane. A pilotless airplane, equipped with an automatic control device said to be more accurate and dependable than any human pilot, has been developed to a point where it has made successful flights of more than ninety miles, the Army Air Service announces.

In actual work with these automatic pilots, hundreds of automatic take offs and a number of automatic flights of ninety miles and more have been made. This "pilot" is capable of being mounted in any type airplane, and in bumpy weather will hold a plane much steadier than a human pilot and will carry it on an absolutely true course, regardless of fog or adverse weather conditions.

Of the automatic pilots being experimented with by the Army Air Service, that which has proved most successful to date can be described as using a gyroscope for its brains and bellows or pneumatics, similar to those used in player pianos, for its muscles.

It was said the invention would have two new methods of bombing; one official asserting it would be entirely practical to load a plane with explosives that would discharge on contact with any target on land or water with great destructive effect.

Other military usages, it was predicted, would be discovered as the experiments continued.

— *Aviation Vol. XIV, No. 1.*

Elimination of Vibration in small rotating machinery is said to be the achievement of Richard Soderberg, mathematical expert of the Westinghouse Electric and Manufacturing Company. His principle has already been tested out in connection with small electric motors, with the result that, when the motors are held in the hand, no vibration can be felt.

In railway work especially the effects of vibration are very noticeable. The elimination of vibration in this connection would permit of faster and more certain service than can possibly be obtained at present.

Solution of Ebonite. The E. H. Clapp Company has patented an interesting process for dissolving ebonite. The solvents are recovered as by-products from the acid treatment of terpene-containing materials.

Substances, such as oil or spirits of turpentine are thoroughly mixed with commercial hydrated crystalline oxalic, about 2.15 to 10 per cent by weight, and the mixture is digested at atmospheric pressure or above at a temperature around 150 degrees C. The mixture is allowed to cool until the oxalic acid separates out. The acid and the product are separated and the acid is completely removed by further washing. The product is subjected to fractional distillation to remove those oils with a boiling point below 202 degrees C. The heavy oil residuum obtained is a solvent of ebonite and hard vulcanized rubber.

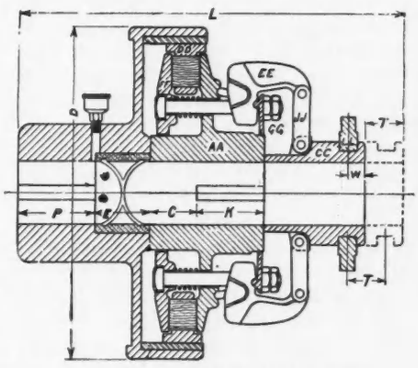
Heavier distillates also possess the property to dissolve hard rubber. The ebonite solution is obtained by stirring into the solvent finely ground ebonite. On exposure to heat the mass solidifies to a rigidity similar to that possessed by the original ebonite.

Duroprene. The *Gummi Zeitung* describes a new treatment of raw rubber by chlorination. The resulting substance has been tested by German rubber chemists and found to possess the following properties: more resistance to acid, alkalies, nitrous gases and other corrosive substances. It has also shown it to be well suited for the production of insulating paper, as well as a cement for stoneware and porcelain.

It was found that articles made of "duroprene" were more lasting than those made of ordinary vulcanized rubber.

Friction Clutch. In recent years power transmission machinery has been cared for in a better manner by having more attention paid to lubrication and adjustments. Also the manufacturers have profited by experience in perfecting their products.

The picture below will give an idea of the construction of the more up-to-date friction clutches of the floating disc type which range in capacity from 1¾ horse power to 480 horse power at 100 R.P.M.



A SECTION THROUGH AN IMPROVED FRICTION CLUTCH
In this type each of the drawbolts may be independently adjusted.

The outer rim covers and protects the friction surface. The toggle mechanism for drawing the friction surfaces together is very powerful and can be adjusted easily to take up any wear that may occur. The draw bolts are evenly spaced and each can be adjusted independently of the other. This feature permits the adjustment of the friction surfaces so there is even pressure at all points, thus maintaining the clutches' maximum efficiency.

The friction discs in small sizes of clutches are made of iron with cork inserted; in larger sizes — 10 horse power and up, — discs are made of iron and fitted with hard wood blocks, the two end grain surfaces of which come in contact with the two iron surfaces of the friction plates. For special service discs are made of iron and instead of being fitted with wooden blocks they are lined with "Non-Burn," a substance having an asbestos base and including several non-inflammable materials having high coefficients of friction and good wearing qualities which are all vulcanized together under high pressure. By increasing the number of discs and friction plates the power transmissible is increased without increasing the diameter of the clutch.

Cracking of Enameled Ware. The Bureau of Standards recently conducted tests to determine the causes of the cracking of enamel on enameled ware and has found that the cracking occurs when the rates of expansion of the enamel and metal differ. The rate of expansion of enamel depends upon its composition and can be adjusted quite accurately to fit that of the metal. The Bureau of Standards has collected a great deal of information on this subject and expects shortly to publish a bulletin giving the compositions of enamel which may be used to the best advantage.

Oil Shale is to replace petroleum as the source of the mineral oil supply of the United States according to the United States Bureau of Mines. The most important deposits of oil shale in this country occur in Colorado, Nevada, Utah, and Wyoming, but there are many deposits of black shale in some of the Eastern States, including Kentucky, Indiana, and Ohio.

The fact that oil shales produce only about forty-two gallons of oil per ton means that to meet the present requirements of the oil industry there would have to be nearly 1,100 shale retorting plants, each able to put through 1,000 tons of shale a day. Thus it will be seen that to supply the 400,000,000 barrels of petroleum produced annually in the United States from shale, would require the mining of 400,000,000 tons of the material, which is very nearly the present volume of coal production in this country.

Thus the amazing sum of $3,000,000,000 would be needed in the construction of retorts and refineries alone. This does not include the cost of lands, the opening of mines, or the development of subsidiary industries, without which, a shale oil industry, as such, could exist. Oil shale is a compact laminated rock of sedimentary origin, which is about 33 per cent ash, and contains organic matter which yields oil when distilled.

Although this oil is not in amounts which are appreciable when extracted with ordinary solvents for oil, the industry has been successful in various countries, prominent among which is Scotland where the investment is more than $12,500,000.

The earliest record of production of shale oil was in Shropshire, England, where "Oyle from a kind of stone" was distilled.

The development of the power possibilities of the Pigeon and Rainy Rivers, boundary streams between Minnesota and Canada, is being considered. The Pigeon Lumber Company has applied to the Federal Power Commission for the privilege of developing five sites on that stream.

— *Power.*

EDITORIALS

CAPS AND GOWNS

Any one who has witnessed the graduation exercises at the Institute has probably experienced a sensation that something was lacking. The simplicity and seriousness of the occasion are impressive but there seems to be an indescribable something which should add dignity and distinction to the ceremony and which is absent. It has been suggested that this situation would be remedied considerably if the students and faculty wore caps and gowns.

This is not a new idea. Last year the proposition was considered, but at too late a date to bring the plans into reality, so the matter has laid on the table until this year. The subject has now been brought to the attention of the Senior class, but up to the time this goes to press no definite action has been taken.

It is a psychological fact that the mere physical raiment of a person is reflected in his thoughts and actions. The king in his gorgeous robes, the workman in his overalls or the student in his dressing gown are examples of fitness to purpose in the matter of dress. So when graduation comes around the matter of the student's costume would impress upon him the dignity of the occasion.

From the point of view of the visitors and onlookers the appeal is perhaps even stronger. Compare, for example, the impression of a military parade when each soldier is dressed alike with that of a Labor Day parade of perhaps the same individuals in ordinary civilian attire. This same impression of uniformity could be gained at graduation if the participants wore caps and gowns.

The Seniors should consider the proposition carefully and if their decision is favorable, the Institute will have made one more step toward the betterment of its graduation exercises.

PROFESSIONAL READING

In the *Military Engineer* there recently appeared, under the title of "Why Do Most Engineers Draw Small Pay?" the following comments:

"This question is propounded and answered by the Editor of *Engineering and Contracting* (June 14, 1922). Based on data relating to the number of engineers who subscribe to the best engineering periodicals, he concludes that most engineers try to distill from their own inner consciousness knowledge to supply their daily needs; that they do not read, and so do not keep abreast of the best thought.

"One of the most common excuses given by the practicing engineer for his failure to read current literature is, 'I am too busy to read.' The author replies: 'Well, maybe that's one reason why you are paid so low a salary. Your employer may not be so dense as you think he is. When he notes that your library is meager and that you are seldom seen digging out information from engineering periodicals, perhaps he says to himself: 'This man is a dead one, in spite of his college education.' "

"It is noteworthy that the man who repeatedly goes to his employer with new plans for reducing costs usually comes to be highly regarded and well paid, provided the plans prove efficacious. It is also noteworthy that the men most prolific in the new economic plans are usually great readers. Reading does not produce originality, but it does furnish most of the elementary ideas out of which new combinations or adaptations are effected.

"Bearing upon this subject the writer quotes Frank K. Walter, librarian of the General Motors Corporation:

" 'The need of books for men in industry is more acute now than ever. Whether it be in agriculture, in the factory, the shop or executive office, a knowledge of the best methods of producing more goods of better quality is imperative. Only in this way can the rising level of prices be met and the high cost of living be mitigated. More than ever before, the experience of all is needed by each. Waste, whether of time, energy or material, is little short of criminal under present conditions. Vocational help through the library is not only permissible, but as necessary as many of the war activities in which the library played so prominent a part.

" 'Industrial corporations are realizing the need of such service and are liberally backing their own special libraries. The man who reads the technical book or the trade paper instead of resting content with what he learns from actual shop practice, is developing the initiative and individuality which have been the chief assets of American industry.' "

These remarks emphasize a fact that is of paramount importance to every college man going into a profession. Everyone can readily call to mind doctors and lawyers who have not kept up with the times. They are hopelessly out of date and instead of doing active, live, progressive work, they but drift through life, "every day in every way" getting deeper and deeper into the rut.

That is the one thing the young man leaving college has a most abiding fear for: the rut. If he would know the preventive he has but to appreciate fully the meaning of the quoted remarks. He must keep up to date, he must appreciate that there is no standing still; engineering marches forward and stragglers certainly cannot be in the front ranks. The way to keep abreast of the times is to read. Technology students will soon find themselves out in the industrial and business worlds where this habit of reading will be of value to them. It would be well for them to form this habit in their college days. There is opportunity aplenty and the wise student will not overlook this opportunity.

LOUIS PASTEUR

A century ago there was born to French parents of the peasant class a son destined to become in the eyes of men an idol, a saint — and even more than either, if it is possible to conceive of such a being. The hindrances due to poverty were surmounted in his upward climb for knowledge through the desire to be a chemist.

The conquests of Pasteur demonstrate two things which should be borne in mind by every scientist. From each observation derive some useful knowledge and then employ the information thus gained to some practical end. Many men are blind to the things which surround them; they

see, but to them the secrets of nature are meaningless for they lack the power of association. This quality by some good fortune Pasteur possessed, and the achievement and mastering of this power came through the desire to make everything turn itself to a practical use.

PROGRESS

Doctor Coué's much used phrase applies very suitably to the latest development in student activities. The action of the Institute Committee in abolishing the time-worn Technique Electoral Committee was a most decisive step towards the improvement of undergraduate activities at Technology.

There is little doubt in the minds of those who have looked into the matter that the Electoral Committee had long ago outgrown its usefulness and had degenerated into a political system which no Tech man could be proud of. Not only was it inadequate but decidedly unfair to the men in other activities where high standards, based on competition, had been set up. The success met with in training, quality of work, and continuity of management obtained by the activities which are established on a competitive basis left little excuse for the further existence of the Electoral Committee.

The Institute Committee is to be congratulated for the way in which it handled this matter. Its action was both constructive as well as destructive. Although making a most sweeping change, it did not leave Technique to shift for itself. Ample plans were made and help is being given to reorganize Technique into one of the highest standard activities at the Institute. Furthermore, by this action, Technique has outgrown its present status as a class activity and becomes a real Technology annual. With this ideal in view, progress in the future is only limited by the quality and quantity of the work done by the members of its staff.

This brings us to the fact that Technique does need the help of the freshman and sophomore classes in its reorganization and it is up to them to get out and work hard for a better year book. Never before has there been a greater opportunity for doing something constructive in the line of student activities and at the same time receiving ample appreciation. The quality of next year's Technique especially depends on the support received from the two lower classes and it is hoped that they will "come through" with the traditional Tech spirit of resourcefulness.

THE A. A. A. S. CONVENTION

It is appropriate that the Massachusetts Institute of Technology should act as host to visiting bodies of learned men; especially men of science. So we are glad that our institution had the honor of acting in this capacity to so large and notable a group as the American Association for the Advancement of Science which held its meetings at Harvard and Massachusetts Institute of Technology during the holiday season.

This association or "league," as it may be called, is really an association of a multitude of societies and individuals operating and interested in a wide variety of scientific subjects. These form a body as a whole whose one accomplishment can be only what its purpose expresses — the advancement of science.

Such a union of so many men, each specializing in a different branch of science, is significant of the real unity that exists among the various branches of science and points toward the ultimate consolidation of our scientific knowledge into a complete and perfect whole. Wonders should be worked with such a clearing-house for information, to which we can turn and ask assistance at any moment we may desire it. This association also serves to popularize science among the masses as well as to form a coöperative union among scientists.

To such organization belongs the credit for the education, in matters of general science, of the man on the street to whom all big projects must turn for "backing."

Thus we have this duplicate effect leading to the accomplishment of this object of advancement — helping the man who does the work and educating his supporters. Best of all is the fact that anyone is eligible for membership in this association which speaks well for its democracy. Surely, the good results that can come from such an institution are inestimable in number and magnitude.

WORDS OF WISDOM

In a recent address to the juniors and seniors of the University of Illinois, Dr. Ira O. Baker, of that institution, flayed technical training that has as its object the mere accumulation of facts in declaring that lack of social graces, conversational ability, and broad knowledge of general matters marks the engineer as an ignorant man no matter how many degrees he may hold.

The cultivation of intellectual power and not the acquisition of technical ability is, according to Doctor Baker, the most important purpose of an education, even though it be an engineering education. For this reason breadth of knowledge, with insight into the fundamental relationships of life — economics, politics, social welfare, government, the relations of capital and labor, law, and human nature — is an essential part of an engineer's training. Initiative gained by attacking the harder problems met in the daily grind of an engineering course, coupled with a broad knowledge and aided by technical ability will produce a superior engineer. Executive ability, calling for an understanding of men, is to be cultivated by participation in student activities. "Infinite good," said Doctor Baker, "will result from rubbing elbows and exchanging views with fellow students, and work on committees will train the student in executing duties."

The final element in engineering success, Doctor Baker thinks, is clear and forceful speaking and writing.

Coming from a man of long experience in training students and studying their performance after graduation, these views should mean much to the undergraduate. The fact that they have been expressed before and will bear repetition again adds greatly to their importance. They may well be considered by the young engineer at Tech for he is just a little inclined to scoff at ideas such as these and to place altogether too much confidence in the value of his degree.

RECOMMENDED ARTICLES

Shot-firing by Electricity, by N. S. Greensfelder, E.M.

A very interesting and valuable paper on the firing of explosive charges which was read before the American Institute of Mining and Metallurgical Engineers. Free copies may be obtained from Hercules Powder Company, Wilmington, Delaware.

Transferation in Office Buildings, News-Letter of the Princeton Engineering Association, June, 1922.

A discussion of the problems of location, round trip time, capacity, and signals in a modern office building by L. Stewart Gatter, Associate Member of the American Institute of Electrical Engineers.

The Human Problem in Industry, Mechanical Engineering, January, 1923.

A paper by E. M. Herr, President of Westinghouse Electric and Manufacturing Company which was read at joint session of the American Economic Association with the American Society of Mechanical Engineers, December 4 to 7, 1922.

THE BALANCING OF ROTATING MASSES

By MAJOR F. JOHNSTONE TAYLOR
British Army

The question of balancing the rotors of steam turbines, electrical plant, large reduction gears, etc., is one of growing importance, due to the enormous centrifugal forces set up by the high peripheral velocities characteristic of these types of machines.

Enormous stresses may be set up by a small unbalance in bodies rotating at a high speed, a study of the theory of engine balancing will show that unbalanced or improperly balanced machinery is subject to abnormal wear, and at high speeds to destructive vibration. It is therefore most necessary that such components as steam turbine rotors, high speed gearing, etc., should be in almost perfect balance after they leave the assembling shops to enable them to withstand high centrifugal forces without setting up disturbances.

This, however, is seldom the case in practice, due to the unavoidable defects in castings, and, in the case of electrical plants, irregularities in weight and assembly of the insulating materials.

For these reasons it is necessary to submit high speed rotors to a series of balancing tests and overspeed trials, to ensure absence of defects in manufacture and assembling and to obtain permanently good balance.

The operation of balancing a rotor should extend through the period of its manufacture, especially in the case of those designed for high speed operation.

The ordinary methods of determining balance resolve themselves into the plane table and knife edge arrangement for ascertaining whether the body is in static balance, and some method of running it in temporary bearings at high speed, and by a suitable arrangement of indicating pointers, ascertaining whether it is in dynamic balance. These methods are common knowledge to mechanics and others accustomed to precision work of this class and need no comment.

As far as dynamic balance is concerned, however, these methods only serve as a guide to show whether the rotor is balanced or not, and correction must be made by trial and error, a somewhat slow and unsatisfactory procedure.

The balancing machine under discussion has been specially designed to overcome these difficulties, and with it, it is possible to determine the position of the center of gravity of any rotating body with regard to its axis of rotation, so that both the moment relatively to the latter and the radial plane of the masses which must be added to or removed from the rotor body in order to balance it, can be ascertained.

An example of the extreme sensitiveness of the machine is to be seen in the fact that when used for balancing a ten-ton turbine rotor six feet in diameter, an overweight of one third of one ounce on its circumference was easily detected. An out-of-balance moment of one inch-pound can likewise be detected with accuracy in rotors and such like.

The general arrangement of a machine of this class adapted for balancing large parts is shown in Fig. 1. It will be seen that it consists of two main portions arranged to carry the shaft of the rotor to be balanced.

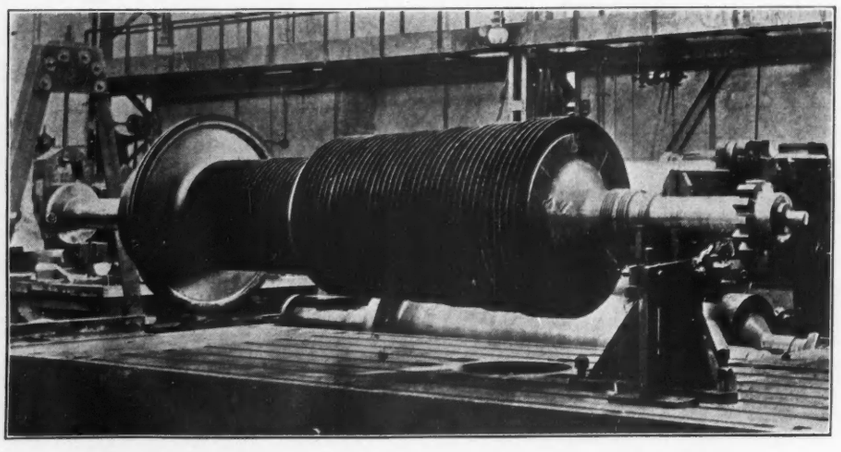


FIGURE 1. TURBINE ROTOR MOUNTED ON BALANCING MACHINE
The further end of the rotor is supported in a ball bearing. The principle of this machine may be used in balancing any rotating mass.

At the far end, the shaft is hung in a universally jointed stirrup. At the near end, it is carried in a bearing which is mounted on the short arm of a steelyard lever.

The lever is provided with a main weight on which rides a jockey weight and is furnished with a knife edge supported in a small column. This is clearly seen in the general arrangement view, Fig. 1.

The rotor to be balanced is placed in the bearings and the main weight of the steelyard is adjusted till the arm is in equilibrium. The rotor is then turned a few degrees, the arm adjusted by the jockey weight and the adjustment recorded.

This procedure is gone through several times till a whole revolution is completed.

The rotor must be lifted clear of the bearing at the steelyard end each time. The results of the weight adjustments referred to are then plotted to a horizontal base, and the sine curve obtained shows a maximum and minimum. These indicate the points at which the center of gravity is furthest from and nearest to the supporting point of the balance.

From the moment given by the jockey weight, multiplied by its displacement, the eccentricity of the center of gravity and the necessary correction are obtained.

Apart from such items as ten-ton turbine rotors, this machine in small sizes is equally accurate when applied to instrument components such as gyro wheels for gyrostatic compasses.

The great advantage of the apparatus in general is that it indicates the correct plane in which the overweight lies and its moment would act.

By any known rotary method of balancing this plane can only be arrived at very approximately. This feature of being able to fix the exact plane is unique to the apparatus under discussion and is the means of obtaining much greater accuracy than hitherto possible. These results are obtained without rotation, it being merely necessary, as shown, to turn the body to six or eight positions. Inertia of the body does not affect this method, nor is there any question of "angle of lag" upsetting the result.

The machine is from the designs of a well-known naval architect and engineer, Mr. W. H. Martin and is now being used by several European turbine builders.

Shoes. *Which kind gets you there the quickest?*

TWO college men were walking down the road, when a classmate whizzed by in his car.

"Pretty soft!" sighed one.

Said the other, "I'll show him. Some day I'll own a car that's got his stopped thirty ways."

The more some men want a thing, the harder they work to get it. And the time to start working—such men at college know—is right now.

All question of classroom honors aside, men would make college count for more if they realized this fact: You can buy a text book for two or three dollars, but you can sell it for as many thousand—once you have digested the contents.

This is worth remembering, should you be inclined to the self-pity which social comparisons sometimes cause. And anyway, these distinctions are bound to be felt, even though your college authorities bar certain luxuries as undemocratic—as perhaps they are.

The philosophy that will carry you through is this: "My day will come—and the more work I crowd into these four years, the quicker I'll make good."

Published in the interest of Electrical Development by an Institution that will be helped by whatever helps the Industry.

Western Electric Company

Since 1869 makers and distributors of electrical equipment

Number 23 of a series

JOHN RIPLEY FREEMAN

(*Continued from page 241*)

talked with the superintendent of the Manchester Mills, a canny old Scotchman whose judgment he valued. The reply which he received was in effect as follows:

"Remember, John, that every family has its skeleton in the closet. If, when you join this new family, you are going to be inquisitive about the skeleton and stop to examine it every time that it makes its appearance you had better not go; but if you think that every time that it appears you can shove it back into the closet and slam the door, you had better go, because the opportunities for you there are probably greater than here."

He went, and it proved a good stepping stone to yet greater responsibilities. During the following period, as chief engineer of these insurance companies, he did important work in standardizing methods and appliances for fire protection, building up the inspection system and department, experimenting upon fire hose and nozzles and fire resisting construction and materials, developing the Underwriter type of fire pump, and trying in all things to standardize and lessen multiplicity of sizes. As evidence of the thoroughness of his experimental work may be cited his experiments relating to hydraulics of fire streams, the results of which were embodied in a paper presented before the American Society of Civil Engineers in November, 1889, and in another before the New England Water Works Association in December of the same year, which stand unchallenged, classics in this field. The former paper won him the coveted Norman Medal. As one trustworthy investigator has said:

"This work has never had to be repeated, which cannot be said of much experimental work in hydraulics."

Two years later he presented another paper before the American Society of Civil Engineers, upon "The Nozzle as an Accurate Water Meter,"[1] which again won him the Norman Medal; and made important experiments at Nashua, New Hampshire, on friction loss in pipes, which he has not yet found time to publish, but which he placed at the disposal of his former chief, Mills, for use in a treatise on which he was working at the time of his death and which will soon be published as a result of Freeman's activities. Shortly thereafter, he presented a paper before the New England Water Works Association, upon "The Arrangement of Hydrants and Water Pipes for the Protection of a City against Fire,"[2] in which were outlined methods for determining the friction loss in water pipe systems, which are still in use.

From his studies of turbines it was an easy step to a pursuit of the theory of the centrifugal pump. The specifications for the North Metropolitan (Boston) sewerage pumps were changed at Freeman's suggestion to admit this type. He presented bids for these pumps, and although he failed to get the contract, by a narrow margin, he had the satisfaction of seeing prevail the type that he had recommended.

His investigations and activities in the insurance field led to his being made President and Treasurer of the Manufacturers', Rhode Island, and Mechanics Mutual Fire Insurance companies, in 1896, and several years later he was put in charge of three more companies which specialize in fire prevention, so that now he has charge of insurance interests of property valued at about two billion dollars, making his office the largest of its kind.

Following the dreadful fire in the Iroquois Theatre in Chicago, in which about two hundred lives were lost, Freeman made a study of the safeguarding of life, from theatre fires, and presented its results in his Presidential address before the American Society of Mechanical Engineers, in December, 1905, — published later in book form.

In 1895–6 he was a member of the Metropolitan Water Board of Boston, but resigned his position when he went to Providence. During this connection he made studies for bringing the water supply to the City by gravity in such a manner as to do away largely with the necessity for pumping, but the development was too far advanced to permit of the adoption of his ideas.

Not content with the demands of his active and rapidly growing mutual factory insurance business, which would have satisfied most men, he steadfastly reserved about half his time for consulting practice in his much loved field of hydraulics, and has made reports upon many important projects, which contain much information new then and as sound to-day as it was when presented by him. It is through these special reports, as well as in his work in the hydraulic experimentation and fire protection fields, that Freeman has shown his strength as an investigator and his appreciation of practical and financial limitations.

"The report by Freeman on the New York Water Supply, to Bird S. Coler, Comptroller of the City in 1900, for clearness of thought and scope of investigation in the time allotted to him" (about seven months) "has not been equalled."

It paved the way for the additional water supply which has since been realized by the City of New York. The *Engineering News-Record* said of it:

"In its printed form it was a book containing about six hundred pages, largely illustrated, and was generally acknowledged to be the most elaborate water works report ever prepared by one engineer."[3]

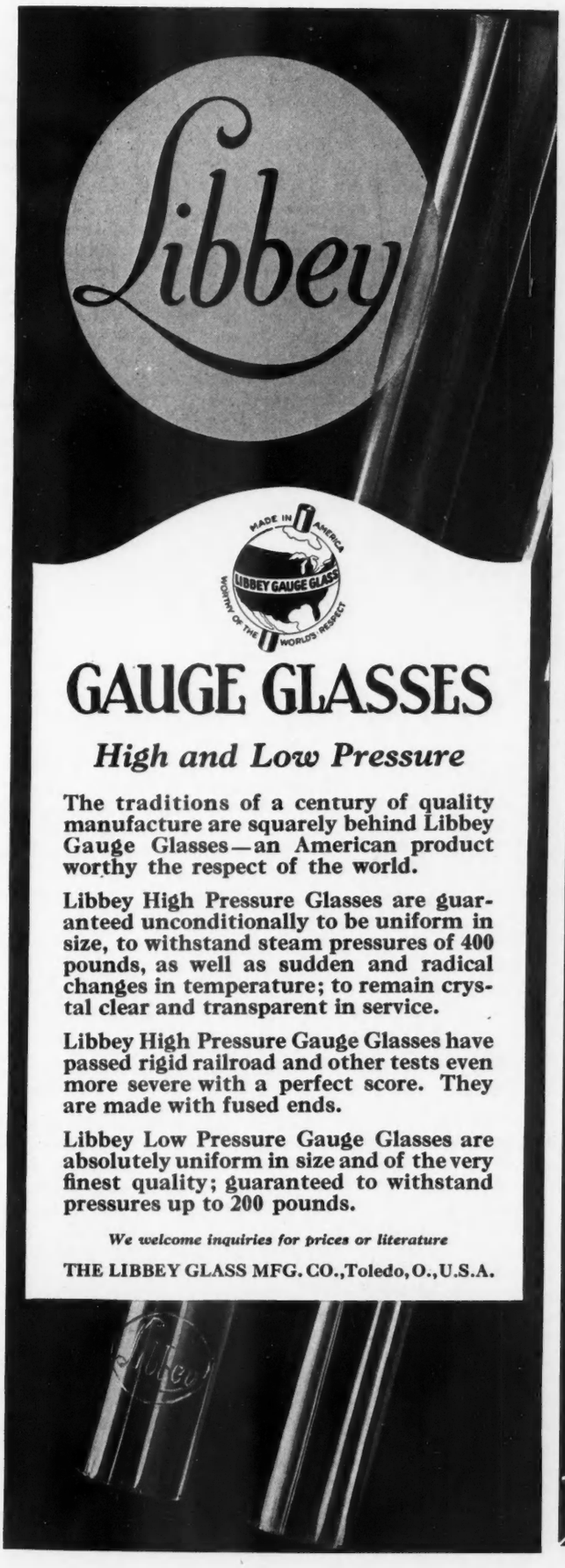
With the design and construction of the additional water supply works, which have since been built, Freeman has been actively connected ever since, being, as a matter of fact, not only the first consulting engineer of the New York Board of Water Supply, but its first employee.

"Hardly less interesting as a piece of engineering literature, is his report submitted as Chief Engineer of the Committee appointed in 1901 to consider the advisability of constructing a dam across the tidal estuary of the Charles River between Boston and Cambridge, for forming a large water park. The report of these studies was a book also of six hundred pages, invaluable to engineers who desire to investigate the subjects of such work for improving the condition of tidal inlets."[3]

Freeman's grasp and thoroughness of study were well shown in this report, in which he seized upon the essentials of his problem and called upon scientists in other fields to aid him in arriving at sound conclusions with respect to certain unusual phases of it. The effect of taking the waters of the Charles River out of the tidal prism of the harbor was at issue with the Army Engineers. The adequacy of the stream flow to take care of pollution and prevent subsequent nuisance, was doubted. The necessity for by-passing the sewage around this basin had not been determined, and the influence of area, depth, salinity and quality of the water, upon probable growths in the basin, was thoroughly studied and reported upon. Traffic upon the river and its use as a pleasure resort, suggested by the Alster Basin at Hamburg, were also studied. These and other questions of lesser import had to be settled before the basic elements of design of the structures involved could be determined. The report, which is still one of great interest to the student, set at rest a bitter controversy that had been going on for about forty

1 Trans. Am. Soc. C. E. Vol. XXIV (1891).
2 Jour. N. E. W. W. A. Vol. VII, 49.
3 Engineering News-Record, January 19, 1922.

(*Continued on page 250*)



GAUGE GLASSES

High and Low Pressure

The traditions of a century of quality manufacture are squarely behind Libbey Gauge Glasses—an American product worthy the respect of the world.

Libbey High Pressure Glasses are guaranteed unconditionally to be uniform in size, to withstand steam pressures of 400 pounds, as well as sudden and radical changes in temperature; to remain crystal clear and transparent in service.

Libbey High Pressure Gauge Glasses have passed rigid railroad and other tests even more severe with a perfect score. They are made with fused ends.

Libbey Low Pressure Gauge Glasses are absolutely uniform in size and of the very finest quality; guaranteed to withstand pressures up to 200 pounds.

We welcome inquiries for prices or literature

THE LIBBEY GLASS MFG. CO., Toledo, O., U.S.A.

HAUGHTON ELEVATORS

10% to 20% Greater Efficiency in Elevator Operation

Haughton elevators have been developed to a very great extent without regard for the practices generally prevailing in the elevator industry.

Building for efficiency first of all, many accepted theories have been discarded whenever better results appeared probable by using some different method.

Instead of building for low first cost, emphasis has always been placed on the importance of the highest possible economy of operation.

As a result, principles of construction have been perfected that have proved in tests to be 10 to 20 per cent more efficient than other standard types of elevator design.

Haughton construction standards also guarantee unusual strength and durability, increasing the life of the equipment and greatly lessening the expense of upkeep and repairs.

Folder with graphic chart showing results of tests mentioned above sent upon request to Department T.

THE HAUGHTON ELEVATOR & MACHINE COMPANY

TOLEDO, OHIO

Toledo	*Cleveland*	*Youngston*
New York	*Detroit*	*Lima*
Pittsburgh	*Akron*	*Oklahoma City*

JOHN RIPLEY FREEMAN

(*Continued from page 248*)

years, and the Legislature forthwith authorized the construction.

Freeman was one of the consulting engineers called to the aid of the United States Government in connection with the construction of the Panama Canal and its locks. He revisited the canal in 1916 with a scientific committee appointed by President Wilson, to study the slides.

The Hetch Hetchy water and power works now being built by the City of San Francisco, were based essentially upon a very thorough investigation[4] made by Freeman in 1912. In this work, too, he showed his realization of the magnitude of the task, by the way in which he called other specialists to his assistance in studying various phases of the problem, the watersheds, the dams, the tunnels, the reservoirs, the conduits, and the possible alternate filtration projects. The entire work was done in an amazingly short time, considering the thoroughness of the investigation and the extent of the material handled. For the last two months of this investigation he was commonly at his desk from five o'clock in the morning to eleven at night.

Freeman has also served other important cities in connection with their water supplies, such as Baltimore, Hartford, Nashua, the City of Mexico, Los Angeles and others. He has served the Canadian Government on many investigations for developing river water powers, and power corporations on large work in the United States and in Mexico, — on the St. Lawrence, the Mississippi and on tributaries of the Sacramento and San Joaquin rivers in California. He made the original layout for the works of the Great Western Power Company.

More recently, in 1917, Freeman was called by the Chinese Government to pass upon important river training problems connected with the rehabilitation of their ancient Grand Canal, and the control of the Yellow River, a stream of about the size of the Missouri, which carries larger quantities of sediment than almost any large river in the world. These investigations incidentally led him, with the capable assistance of Prof. Hardy Cross, '08, to compile abstracts of everything written on river hydraulics, that could be found in about ten of the greatest scientific libraries, and to make examinations of the work of the English engineers in India, for improved river navigation and bridge crossings. He put in a bid for the proposed new railroad bridge for the Hankow Railroad across the Yellow River, in which he proposed to so train and narrow this river here that a bridge only one-fifth as long as the present bridge (which is two miles long) would serve.

His intense interest in river control has recently appeared in his effort to bring about the establishment of a National Hydraulic Laboratory where problems of river training, etc., could be effectively studied, as appears in the record of a hearing before the subcommittee of the Committee on Commerce, of the United States Senate.[5]

Freeman has shown a deep interest in scientific training for many years, and for the past twenty-five years has been a member of the Corporation of the Institute. His travels at home and abroad have enabled him to keep in touch with developments in this line, to the advantage of his Alma Mater and its instructing staff. He prepared, at the request of President Maclaurin and the Executive Committee of the Technology Corporation, outline plans for the new Institute buildings, based on studies of more than forty groups of college buildings in America and Europe "from the viewpoint of an industrial engineer," in which economy, efficiency, light and ventilation were made paramount. It was his idea that some one with more architectural skill than himself should plan the exterior. Although these plans were not followed, they gave many suggestions which were embodied in the final plans.

In the field of the professional societies, too, Freeman has given effective service and unstintedly of his time. He has served as a member of the boards of direction of many national and local societies. He is a past president of the American Society of Mechanical Engineers, and of the Boston Society of Civil Engineers, and is now President of the American Society of Civil Engineers.

Freeman's life should be of interest to every young engineer in the Institute, for it reflects the results of hard conscientious work on the part of one who studies his problems with thoroughness, who is quick in his perception of the possible influence of other scientific fields upon his own, and whose course has been touched by the romance and idealism of engineering.

4 "The Hetch Hetchy Water Supply for San Francisco, 1912," by John R. Freeman (465 pages).

5 S. J. Res. 209 to Establish a National Hydraulic Laboratory, Sept. 8, 1922.

THE MACHINE TOOL LABORATORIES AT TECHNOLOGY

(*Continued from page 237*)

problem courses in well-equipped laboratories that the students are able to enter shops and factories and operate satisfactorily machines that they have never seen before.

The laboratory method of teaching is truly an unselfish system, it does no needless repetitional work, neither does it commercialize the efforts of the students. The introduction of commercial or repetitional work in a machine tool laboratory course eliminates variety, that powerful factor in any educational system, and prevents rapid progress. No other system has so efficiently trained men as has the laboratory method.

The tremendous energy and earnestness awakened in students when they realize how quickly they obtain accurate results and how rapidly they advance, are effective agents in making the laboratory method so successful and practical. No word is more misleading in industrial education than the word practical. We frequently hear it stated, with a spirit of pride, "We give our boys practical work." The so-called practical work of construction and repetition is the most impractical work for the boys' advancement.

The laboratory method, which may truly be called a high pressure system of teaching, is the most practical for the learner, and it is the only true solution of rapidly, economically, and progressively supplying the information and teaching the art and skill of the mechanical trades.

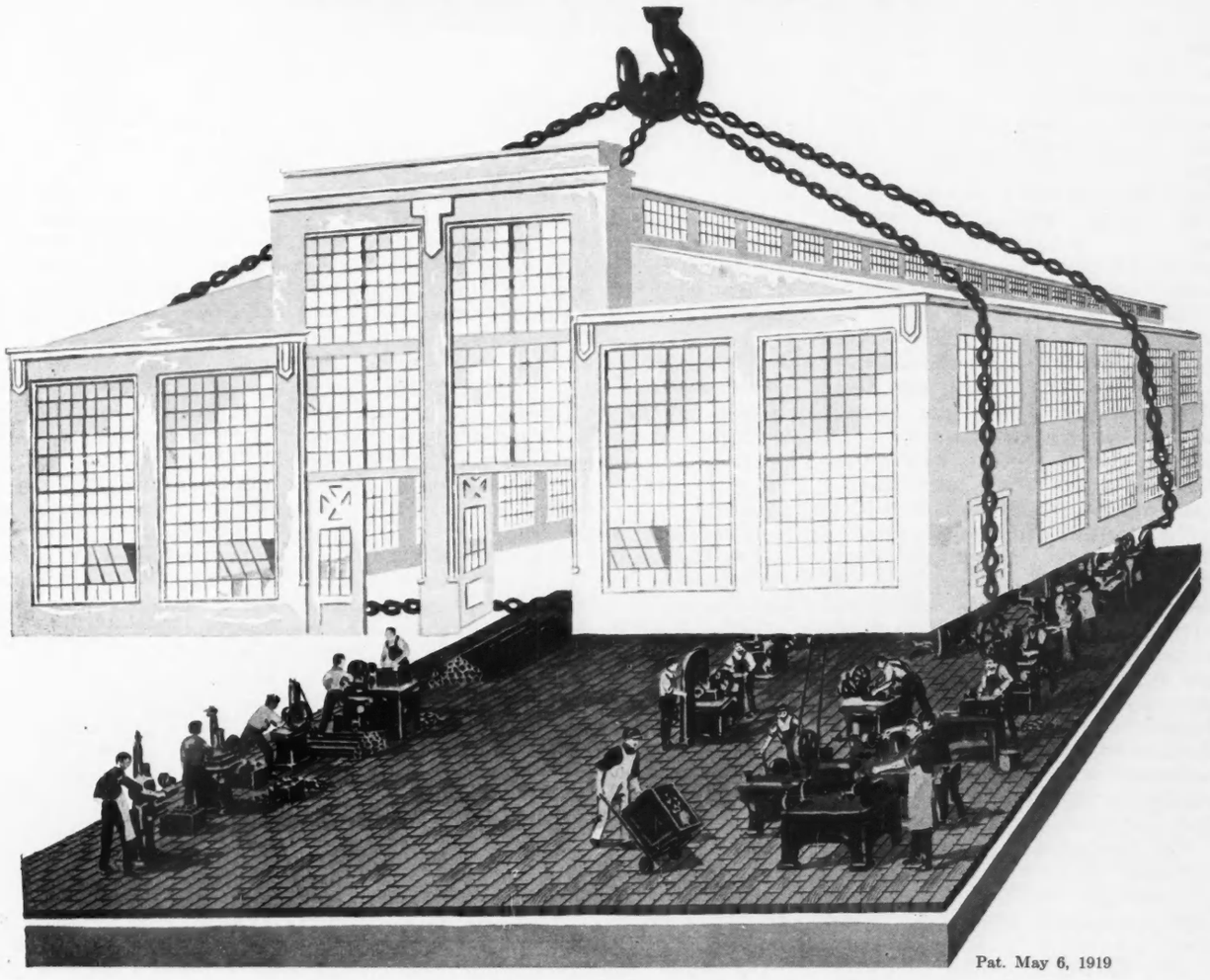
Students are given instruction in making measurements with light waves on gages, balls, ball bearings, measuring wires, and thread gages; in measuring parallelism and flatness of surfaces; and in determining small tolerances in working and inspection gages.

The wonderful progress in the development of machinery proves that the accuracy of man's work is limited only by the measuring instruments available.

Students at the Massachusetts Institute of Technology are taught to make all kinds of measurements from the wooden rule to light waves, to measure to the ten thousandth, hundred thousandth, and even to the millionth of an inch.

KREOLITE WOOD BLOCK FLOORS

Outlast the Factory



Pat. May 6, 1919

The Floor is the *Producing* Part

Remove the factory side walls and roof — you do not **stop** production — you simply **expose** it to the elements and outside distractions.

On the floor of the factory machines hum, men labor, products move along to completion. And the expedition and economy with which they move is governed entirely by the floor **assistance** or **resistance** encountered.

Kreolite Wood Block floors are fast displacing other types.

All kinds of manufacturers have found no other material so permanent, so resilient, so saving and so helpful to men, machines and production efficiency.

Kreolite's patented process by which the blocks are impregnated with Kreolite Preservative Oil, makes them impervious to moisture from above and below. And its exclusive design provides grooves which, filled with Kreolite binder pitch, make the floor a single unit of such durability that it **outlasts the factory.**

Kreolite Wood Block floors are especially adapted for use in machine shops, foundries, paper mills, tanneries, loading platforms, and stables.

Our Factory Floor Engineers are ready at all times to co-operate fully, without obligation. Send for our service or write for our book on Kreolite Floors. Write the Toledo Office.

The Jennison-Wright Company, 86 Kreolite Building, Toledo, Ohio

WHAT IS THE ORIGIN OF THE EARTH?

(*Continued from page 233*)

in one direction relative to the surface of the sun.

If we inquire into the question of a temporary reduction of the sun's gravitative power the most probable cause for such a change would be the close approach of some other stellar body. Such a body would be travelling and as it passed through the sun's gravitative field the gravity of both bodies would be reduced along the line of mutual attraction. The effect of the passage of a stellar visitor within the sun's domain would be to pull material not only out of one side of the sun but out of opposite sides according to the tidal principle; and all this disrupted material would be given a lateral motion so that after the visitor had passed off into space the material would be left revolving around the sun all in the same direction and all more or less in the same plane.

As we look out through the galaxy of stars in space we see an apparently well ordered dynamic scheme. We see nothing that is left to chance. The countless stellar bodies sweep through space as units in a great system, their paths of definite form and their relationships to one another maintained. It is not logical to assume then that the close approach of some other star to the sun, if such did take place, would be a chance event but most probably it would be a part of the scheme and perhaps a recurrent event. Indeed there are certain features of the solar system which cannot well be reconciled with an hypothesis based on the assumption of a single disruption of the sun.

The planets are arranged in two distinct and markedly dissimilar groups — consisting of the outer planets: Jupiter, Saturn, Uranus, and Neptune; and the minor planets: Mercury, Venus, Earth, and Mars. These two groups are radically different. The members of the outer group are all large, their densities are all low, and they are, at least in their outer portions, gaseous or finely divided. On the other hand the members of the inner group are all small, their densities are all high, and they are solid.

Now if all the planetary material had been ejected from the sun during the same period of disruption the planets should all consist of the same material. If this were the case the low densities of the outer planets could only be the result of high temperature. But in this case their densities should be at least higher than that of the sun since they are not and cannot be as hot. In fact, we know that some of them at least are cold and non-luminous. Uranus has a density only slightly higher than the sun while that of Saturn is much lower. Their low densities, then, are seemingly due to their inherent composition and this composition is apparently very different from that of the inner planets and the sun itself. But we have assumed solar parentage for all the planets. How then could these outer planets be the offspring of a sun of different composition?

Stars, or suns, undoubtedly pass through an evolution from the simple to the complex — from birth to death. Transmutation from the simple to the complex, during stellar evolution, through electronic regrouping stands as the foundation of the modern conception of the constitution of matter. At one time the sun was a star of larger dimensions and of more simple composition.

If we assume then a dispersion of solar material through the disruptive approach of the visiting star at a time when the sun was of more simple composition, this would seem to explain the characteristics of the outer planets. Much later, when the sun had passed well on in its evolutionary cycle, a second dispersion would give rise to the material of the inner planets including the earth.

If the outer planets are the products of an earlier solar disruption at a time when the sun had a more simple constitution, they would inherit this constitutional simplicity except in so far as evolution toward the complex would continue in them. We do not know the physical state or states which give rise to this evolution. Mass may be, and probably is, a factor.

The best evidence of the constitution of the outer planets is not to be sought in the planets themselves, for they, if not entirely gaseous, are deeply enveloped in vaporous or finely divided material; but in certain satellites which are attached to the planets, especially the first four satellites of Jupiter. These bodies have densities from 1.0 to 2.0; they are of the large order of satellitic bodies; have no appreciable atmospheres, and are solid. It is to be presumed that the density of the material of their surficial portions is somewhat less than their densities as a whole. These bodies seem to be composed of some material whose density is about 1.0.

The suggestion of a two-fold disruption of the sun is new. It has not as yet been subjected to the scrutiny of students of celestial dynamics. It is merely an attempt to explain the evident differences in the two groups of planets. But there are yet other apparent anomalies in the solar system. Can these be reconciled with a two-fold dispersion?

Between Saturn and Mars is a host of minor planets called the Asteroids. Several of these bodies are a few hundred miles in diameter but most of them are smaller. In so far as known, their densities are about 3.4, comparable to that of the planet Mars and the moon. These are solid bodies and belong distinctly to the inner group of planets. The absence of any outstandingly massive body in the group probably accounts for the lack of segregation. The prevailing features of the Asteroids are the high eccentricity of their orbits and, in so far as known, their irregularity of form. One indeed, Eros, has an orbit which brings it within the orbit of the planet Mars and its form seems to be that of a flattened pear. Eventual entrapment, perhaps as a satellite, by the planet Mars would seem to be its evident fate. It may well be that the present two diminutive satellites of Mars are entrapments from the Asteroid host. The anomalous rapidity of the revolution of Phobos, the inner Martian satellite, indicates an origin extraneous to that planet. Indeed the thought arises that perhaps the moon may be an entrapped Asteroid. Its density corresponds and its uniquely pitted surface is difficult to reconcile with a history of harmony with that of the earth. The lack of similar features on the earth is difficult to explain away by the simple statement that the erosive agencies are active on the earth and absent on the moon. If these moon craters are volcanic, their type is not present on the earth. If these features of the moon are the result of impact with other bodies the best place to have received such scars would be, not in the vicinity of the earth, but among the Asteroid swarm.

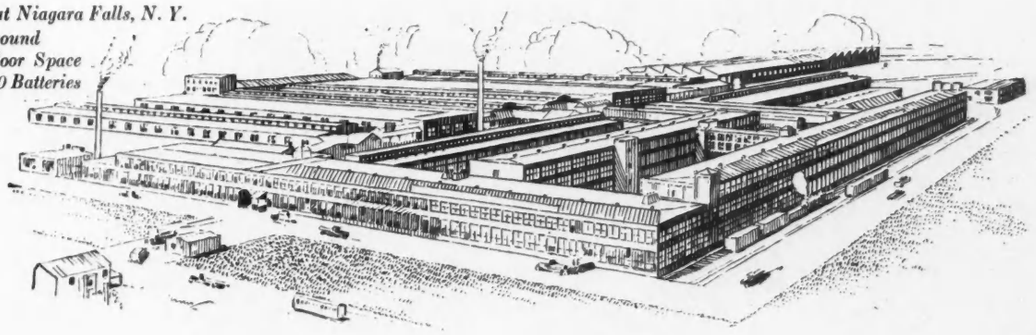
Satellite IX of Saturn has the distinction of being the only body of the solar system which has a retrograde revolution, revolving in the reverse direction to all the other satellites of that planet. A moment's consideration will show that if a small body is projected into the sphere of gravitative control of a more massive body and becomes entrapped as a satellite its direction of revolution will depend upon which side of the entrapping body the entrapped body passes.

These anomalous bodies would seem but to corroborate the hypothesis of a two-fold, widely separated disruption of the sun. At least there is nothing in these anomalies which renders such an hypothesis untenable.

The material drawn off or thrown

(*Continued on page 254*)

USL Factory at Niagara Falls, N. Y.
32 Acres of Ground
10 Acres of Floor Space
Capacity 10,000 Batteries per Day



THOSE WHO APPROVE USL BATTERIES

1. *The automobile manufacturers*

Sixty-one makes of automobiles now use USL batteries as standard equipment. Of seven automobile makers who changed batteries in 1922 five changed to USL, while five of the six new cars launched in 1922 chose USL. Not one car manufacturer who has used USL batteries within the past three years has changed from the USL. This outspoken approval by automobile manufacturers is matched by the approval evidenced by the battery service men.

2. *The battery service stations*

The number of USL distributors and service stations increased 61 per cent during 1922. Today more than 5,500 battery stations in all parts of the country stand back of USL storage batteries. Both the automobile manufacturer and the service station realized the necessity and importance of public approval when they chose USL batteries.

3. *The public*

Recently 75,000 owners of fifteen different makes of automobiles equipped with the four leading batteries were questioned by an independent agency about their batteries. USL stood second to none in their esteem, and only one other battery was accorded equal standing.

USL Radio Batteries

Abreast with the times the U. S. Light & Heat Corporation has put their twenty-two years of successful battery making into the development of the famous USL Radio batteries. Today the plants are working day and night to meet the demand for USL Radio "A" and "B" batteries which include 6 volt, Radio "A" batteries in rubber or mahogany finished oak cases with capacities ranging from 30 to 140 ampere hours and 24 volt "B" batteries in hard rubber cases with 2 ampere hour capacity. Radio demands and deserves the best. We have tried to meet these demands. *As to what radio experts think of USL see page 28, January 6th Literary Digest.*

U. S. LIGHT & HEAT CORPORATION

NIAGARA FALLS, N. Y.

U. S. Light & Heat, Limited
Niagara Falls, Ontario

U. S. Light & Heat Corporation
of California, Oakland, California

USL TRADE MARK
U. S. LIGHT & HEAT CORPORATION

storage batteries

WHAT IS THE ORIGIN OF THE EARTH?

(*Continued from page 252*)

off from the sun would be irregularly and perhaps finely dispersed, and gaseous at first since it was derived from a gaseous body. The gathering together of this material into the planetary bodies constitutes the next step in the evolutionary scheme. The larger masses would attract the smaller, both by gravitative pull and by coalescence through collision. Thus we may picture the larger masses as passing through a period of growth, clearing up interplanetary space. But even now additions are made. Look out into the starry night — a streak of light suddenly crosses the sky — a long lost planitesimal adds itself to the earth. In the very early stages of growth the hemisphere of night must have continuously scintillated with a myriad of falling bodies.

To summarize, then, we may set down as basal postulates:

1. A parent star — the sun — which has passed through its normal course of evolution from a large body of simple composition to the present smaller body of complex composition.

2. That the sun has suffered two partial disruptions, one at a time early in the sun's evolution, the other at a much later period.

3. That the disrupting impulse was due in each case to the passage of a stellar visitor through the sun's domain of space.

4. That the dispersed material gathered together into the planets of the present system.

Fortunate indeed has been the fate of the earth in this planetary evolution — whatever that evolution may have been — that she has been given such a mass and such a position in space so as to be capable of retaining those elemental gases which constitute the life-giving atmosphere, and that she receives and holds just so much of the sun's radiant energy as to maintain the comparatively narrow range of temperature within which life can exist.

If we dare attempt to fathom the time past and if in the attempt we seem to see an orderly sequence of events, may we not also attempt to look into the future? If the partial disruption of our parent sun is a recurrent event in the life cycle of the planetary system, is it not feasible to assume that the disturbing visitor will again follow its ordered path through the sun's domain, and with what results? Will it add to the system yet another group of planets or will it cause such disturbance as to sweep away the earth and its sister planets as a wasted effort and begin again the re-creation of a new system; or will this event be so far distant in time that the sun will have completed its evolutionary cycle and be a non-radiating cold body travelling on through the blackness of space, carrying with it its family of dead planets enveloped in the perpetual darkness of night.*

WILLIAM F. JONES.

*Author's Note: — It must be understood, of course, that there are several hypotheses of the origin of the earth. It would not be feasible in a short article to compare or debate the several ideas.

See: "The Origin of the Earth," by T. C. Chamberlin, University of Chicago Press.

"The Evolution of the Earth," by Joseph Barrell, Yale University Press.

ELASTICITY AND HOOKE'S LAW

(*Continued from page 238*)

For that reason it cannot be isolated as far as the effect of the rolls is concerned by sawing kerfs in the top or bottom of the bar as it has passed through the roll, but the effect of quenching on the side of the bar can readily be isolated in this way in the same manner as the residual strain in the cold bent bar was determined in "Concrete Steel Construction" by Eddy and Turner.

K is reduced as the bar acquires residual strain and as the set is in the direction of the displacement curves, it is in order to inquire how the value of F is affected by acquiring residual strain. Since the material has undergone no overstrain in the direction of the equi-potential curves and the direction in which rotational distortion takes place is in the direction of the equi-potential curves, F remains numerically constant while K and E are changed by overstrain.

Accordingly, as F is *numerically an invarient of residual strain* the limit of increase in the value of E due to working the material within the elastic limits thereby reducing the state of residual strain can be computed from the formula that $(1+K)=E/2F$ and we at once find that the limit of improvement in the elastic resistance of mild steel having a modulus of E of 29,000,000 pounds as received from the mill, is limited closely to 1,500,000 pounds increase by working the metal back and forth well within the elastic limits as found by Bauschinger in his investigation which indicates that sound metal so far from being damaged by repeated stress was actually improved in elasticity, ductility, and tenacity in the absence of flaws.

The definite relation thus established between the curves of principal strain and the curves of displacement and equi-potential permits simple graphic analysis of problems of torsion and flexure which have heretofore been solved only by differential equations of the "nth" degree. The discovery of these fundamental relations eliminates at once the inconsistencies and discrepancies between elastic theory and the results of experimental work. It shows that the application of Hooke's law is limited strictly to the relations of the kinetic moduli and cannot be exactly applied to the static moduli or deformation of the material.

Errors in and inconsistencies of the common theory of flexture are readily corrected and by such correction the deflection of Bethlehem girder beams is found to be exactly that which would be computed for ordinary beams, the steel being the same and having been subjected to the same heat treatment.*

The lines of greater shear, equi-potential, curves of displacement, and contours of uniform plates bent in synclastic or anticlastic curvature may be worked out without any difficulty by this theory. St. Venant's curves of displacement in the torsion of a square shaft may be readily drawn with precision and similar problems which heretofore have required mathematical ability of a high order to solve, become as simple as the parallelogram of forces. The angularity of displacement lines which come into relief on the polished surface of a piece of mild steel when it is strained slightly beyond the yield point in like manner are readily computed with precision, so that this theory of the mechanics of elasticity accounts for all phenomena including the fatigue tests of Woehler without supposing that the material has been injuriously affected provided the static intensity of the stress has not exceeded the natural limits of elasticity.

The attached figure shows the displacement curves and curves of equi-potential in an ordinary steel bar under tension. It explains why expanded metal mesh is more efficient for the same cross section than plain rods of the same material in cylindrical bending. It further explains why the same expanded metal is quite inefficient and not to be compared with crossed rods in plate action of reinforced concrete since the effect of the bridge is quite detrimental in plate action but an advantage in cylindrical bending.

*For such tests, see Engineering News, Feb. 24, 1910, page 228.

HALF A CENTURY OF FAITHFUL SERVICE

"I am enclosing two pictures of Gamewell Boxes that have been in continuous service since 1887, and to the best of my knowledge they have never failed to register an alarm. This is remarkable, as the atmospheric condition of the Ohio Valley is subject to many changes such as heavy fogs, fumes of sulphite, sulphur, etc. All factories and steel mills use soft coal and the air is charged with sulphur at all times. These conditions have a tendency to cause corrosion of all metal exposed to the weather, as I know an entrance switch or porch electrical fixture will corrode and fall to pieces within two or three years."

E. D. RICHARDS
City Electrician
Steubenville, Ohio

FIFTY-THREE years ago this Gamewell Box No. 25 was installed on a street corner in Troy, New York. Through storm, sleet and sunshine it stood guard over homes and factories and never once was found unfaithful. Two years ago when Troy reorganized its fire alarm system this old veteran was honorably retired and is today occupying a place of honor in our museum.

TWO other cities, Lawrence, Massachusetts and Milwaukee, Wisconsin today have boxes in service which were installed in 1869, the same year as this box. One hundred and ninety other cities have boxes in active service today which have stood on the street corners for twenty years or more.

FRANKLY, we are a bit proud of the New England Craftsmen who made these records possible. With their record before us and with the knowledge that lives rest on the proper action of a fire alarm box—we are working today to build boxes that will give this same faithful service.

The Gamewell Company

Newton Upper Falls, Mass.

WHAT IS THE ORIGIN OF THE EARTH?

(*Continued from page 252*)

off from the sun would be irregularly and perhaps finely dispersed, and gaseous at first since it was derived from a gaseous body. The gathering together of this material into the planetary bodies constitutes the next step in the evolutionary scheme. The larger masses would attract the smaller, both by gravitative pull and by coalescence through collision. Thus we may picture the larger masses as passing through a period of growth, clearing up interplanetary space. But even now additions are made. Look out into the starry night — a streak of light suddenly crosses the sky — a long lost planitesimal adds itself to the earth. In the very early stages of growth the hemisphere of night must have continuously scintillated with a myriad of falling bodies.

To summarize, then, we may set down as basal postulates:

1. A parent star — the sun — which has passed through its normal course of evolution from a large body of simple composition to the present smaller body of complex composition.

2. That the sun has suffered two partial disruptions, one at a time early in the sun's evolution, the other at a much later period.

3. That the disrupting impulse was due in each case to the passage of a stellar visitor through the sun's domain of space.

4. That the dispersed material gathered together into the planets of the present system.

Fortunate indeed has been the fate of the earth in this planetary evolution — whatever that evolution may have been — that she has been given such a mass and such a position in space so as to be capable of retaining those elemental gases which constitute the life-giving atmosphere, and that she receives and holds just so much of the sun's radiant energy as to maintain the comparatively narrow range of temperature within which life can exist.

If we dare attempt to fathom the time past and if in the attempt we seem to see an orderly sequence of events, may we not also attempt to look into the future? If the partial disruption of our parent sun is a recurrent event in the life cycle of the planetary system, is it not feasible to assume that the disturbing visitor will again follow its ordered path through the sun's domain, and with what results? Will it add to the system yet another group of planets or will it cause such disturbance as to sweep away the earth and its sister planets as a wasted effort and begin again the re-creation of a new system; or will this event be so far distant in time that the sun will have completed its evolutionary cycle and be a non-radiating cold body travelling on through the blackness of space, carrying with it its family of dead planets enveloped in the perpetual darkness of night.*

WILLIAM F. JONES.

*Author's Note: — It must be understood, of course, that there are several hypotheses of the origin of the earth. It would not be feasible in a short article to compare or debate the several ideas.

See: "The Origin of the Earth," by T. C. Chamberlin, University of Chicago Press.

"The Evolution of the Earth," by Joseph Barrell, Yale University Press.

ELASTICITY AND HOOKE'S LAW

(*Continued from page 238*)

For that reason it cannot be isolated as far as the effect of the rolls is concerned by sawing kerfs in the top or bottom of the bar as it has passed through the roll, but the effect of quenching on the side of the bar can readily be isolated in this way in the same manner as the residual strain in the cold bent bar was determined in "Concrete Steel Construction" by Eddy and Turner.

K is reduced as the bar acquires residual strain and as the set is in the direction of the displacement curves, it is in order to inquire how the value of F is affected by acquiring residual strain. Since the material has undergone no overstrain in the direction of the equi-potential curves and the direction in which rotational distortion takes place is in the direction of the equi-potential curves, F remains numerically constant while K and E are changed by overstrain.

Accordingly, as F is *numerically an invarient of residual strain* the limit of increase in the value of E due to working the material within the elastic limits thereby reducing the state of residual strain can be computed from the formula that $(1+K)=E/2F$ and we at once find that the limit of improvement in the elastic resistance of mild steel having a modulus of E of 29,000,000 pounds as received from the mill, is limited closely to 1,500,000 pounds increase by working the metal back and forth well within the elastic limits as found by Bauschinger in his investigation which indicates that sound metal so far from being damaged by repeated stress was actually improved in elasticity, ductility, and tenacity in the absence of flaws.

The definite relation thus established between the curves of principal strain and the curves of displacement and equi-potential permits simple graphic analysis of problems of torsion and flexure which have heretofore been solved only by differential equations of the "nth" degree. The discovery of these fundamental relations eliminates at once the inconsistencies and discrepancies between elastic theory and the results of experimental work. It shows that the application of Hooke's law is limited strictly to the relations of the kinetic moduli and cannot be exactly applied to the static moduli or deformation of the material.

Errors in and inconsistencies of the common theory of flexture are readily corrected and by such correction the deflection of Bethlehem girder beams is found to be exactly that which would be computed for ordinary beams, the steel being the same and having been subjected to the same heat treatment.*

The lines of greater shear, equi-potential, curves of displacement, and contours of uniform plates bent in synclastic or anticlastic curvature may be worked out without any difficulty by this theory. St. Venant's curves of displacement in the torsion of a square shaft may be readily drawn with precision and similar problems which heretofore have required mathematical ability of a high order to solve, become as simple as the parallelogram of forces. The angularity of displacement lines which come into relief on the polished surface of a piece of mild steel when it is strained slightly beyond the yield point in like manner are readily computed with precision, so that this theory of the mechanics of elasticity accounts for all phenomena including the fatigue tests of Woehler without supposing that the material has been injuriously affected provided the static intensity of the stress has not exceeded the natural limits of elasticity.

The attached figure shows the displacement curves and curves of equi-potential in an ordinary steel bar under tension. It explains why expanded metal mesh is more efficient for the same cross section than plain rods of the same material in cylindrical bending. It further explains why the same expanded metal is quite inefficient and not to be compared with crossed rods in plate action of reinforced concrete since the effect of the bridge is quite detrimental in plate action but an advantage in cylindrical bending.

*For such tests, see Engineering News, Feb. 24, 1910, page 228.

HALF A CENTURY OF FAITHFUL SERVICE

"I am enclosing two pictures of Gamewell Boxes that have been in continuous service since 1887, and to the best of my knowledge they have never failed to register an alarm. This is remarkable, as the atmospheric condition of the Ohio Valley is subject to many changes such as heavy fogs, fumes of sulphite, sulphur, etc. All factories and steel mills use soft coal and the air is charged with sulphur at all times. These conditions have a tendency to cause corrosion of all metal exposed to the weather, as I know an entrance switch or porch electrical fixture will corrode and fall to pieces within two or three years."

E. D. RICHARDS
City Electrician
Steubenville, Ohio

FIFTY-THREE years ago this Gamewell Box No. 25 was installed on a street corner in Troy, New York. Through storm, sleet and sunshine it stood guard over homes and factories and never once was found unfaithful. Two years ago when Troy reorganized its fire alarm system this old veteran was honorably retired and is today occupying a place of honor in our museum.

TWO other cities, Lawrence, Massachusetts and Milwaukee, Wisconsin today have boxes in service which were installed in 1869, the same year as this box. One hundred and ninety other cities have boxes in active service today which have stood on the street corners for twenty years or more.

FRANKLY, we are a bit proud of the New England Craftsmen who made these records possible. With their record before us and with the knowledge that lives rest on the proper action of a fire alarm box—we are working today to build boxes that will give this same faithful service.

The Gamewell Company

Newton Upper Falls, Mass.

HEATING BUILDINGS BY FUEL OIL

(Continued from page 240)

velocity and the centrifugal force due to this spin is sufficient to break up the issuing jet into a well defined cone of finely divided oil drops. And third, rotary burners. These consist of a rotating metal cup, into which the oil is fed. It is thrown out as a fine mist at the edge of the cup. This mist is formed into a jet by a blast of low pressure air, which issues from an annular orifice surrounding the cup. These burners are shown in their elements in figures 1, 2 and 3 respectively. In all cases the combustion air is introduced into the furnace through orifices surrounding or near the burner.

When burning the heaviest oils combustion is improved, and the pumping of the oil is facilitated by heating it. This is essential in the case of mechanical burners, as the cold oil is too viscous to receive the necessary spin and will in most cases not burn at all. The temperature should always be kept below that at which carbon forms so as not to clog the burner orifice.

Steam jet and rotary burners do not require such high oil temperatures and will burn most commercial heavy oils at 60°F after a fashion. However, the droplets are smaller when the viscosity is reduced and combustion is, in general, improved by heating. Oil may be heated by passing it through coils surrounded by steam or hot water or by means of electric resistance elements. The suction pipe in the storage tank is frequently surrounded by steam coils, which heat the oil slightly and assist in pumping it.

All the above burners require some form of pump to supply them with oil, as gravity flow under small head is unsteady, and is in many cases prohibited by fire prevention rules. Simplex or duplex steam pumps are usually used with burners of the first and second classes. Steam jet burners require only enough pressure to insure a steady flow of the oil but the mechanical burners usually take oil at from one hundred to two hundred pounds per square inch, and large expansion chambers are to be recommended in the pump discharge lines. The rotary burners on the market at present usually depend upon motor drive so that gear pumps are used in most cases. Here again only a low pressure to secure steadiness of flow is required.

One of the peculiarities of oil burning is that an oil fire cannot be started in a cold boiler without external energy, such as electricity, compressed air, or steam from another boiler, and this question must be considered in each plant. Auxiliary motor driven pumps and electric heaters are frequently used. In some cases it is satisfactory to raise steam by a wood fire.

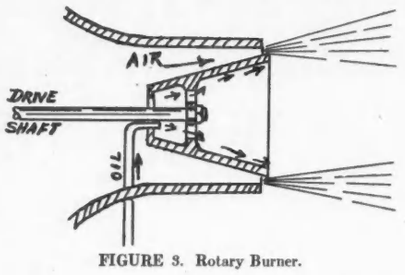


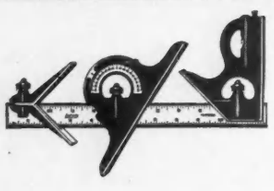
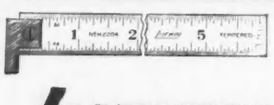
FIGURE 3. Rotary Burner.

Each of the three types of burners described above has its own field of usefulness. Comparing the steam jet with the mechanical type, the former system is cheaper to install but uses from two to eight per cent of the steam generated in the boiler for atomising, depending on the care with which the jet is manipulated. The mechanical burner is more economical by approximately the above amount of steam, and is to be recommended for large installations where boiler efficiency is of greatest importance. It cannot be satisfactorily used in units smaller than one hundred boiler horse power per burner as the central orifice in the burner tip becomes so small that it tends to clog.

For low pressure heating, *i.e.*, with steam pressures lower than fifteen pounds per square inch, the rotary burner stands alone if heavy oil is to be burned. Figure 4 shows a successful heavy oil rotary burner with gear pump blower and atomiser cup driven from the same shaft. This burner can be started satisfactorily with cold oil, though it is usually installed with a small coil heater mounted on the boiler. Oil is drawn through the heater into the gear pump, and the amount required for combustion is regulated by a pressure regulator. The excess oil passes through a pressure relief valve back into the storage tank. This keeps the oil in the tank warm.

A number of burners have been developed for burning kerosene and light fuel oil in smaller apartment houses, homes, etc. These are mostly air jet burners or rotary burners and are highly automatic in their operation, being controlled by a thermostat located in one of the rooms to be heated. They are mostly intermittent in their operation and require a gas pilot to light the flame. As stated above these burners would be regarded in the light of conveniences rather than fuel savers as their fuel cost is about equivalent to that of hard coal at present prices of oil and coal. Due to their low price and wide application they are now being installed in considerable numbers.

Coming now to the question of fuel consumption if we take the lower heating values of 15° Baume Unacan oil as 151,000 b.t.u. per gallon and that of coal as 13,500 b.t.u. per pound, we arrive at the equivalence of 179 gallons of oil to one ton of coal. In the case of large boilers under a steady and continuous load with very good coal firing this condition would almost obtain. When, however, we consider the amount of unburned coal in the ash, and the inefficiency of combustion when the fire is banked and when dirty, in the average heating boiler the oil makes a more favorable showing. For the average apartment house or garage 150 gallons to the ton should be realized. In some buildings, as for example, schools, heat is required during only a part of the day. Oil makes a very favorable showing in such cases, as it can be shut off immediately when desired, and steam be raised in the morning in a few minutes.



LUFKIN

MECHANICS TOOLS
TAPES—RULES
RELIABLE, PROGRESSIVE LINES
Not only made from the best of materials, but having improved, exclusive features
SEND FOR CATALOGUE
THE LUFKIN RULE CO.
SAGINAW, MICHIGAN
London, England
New York
Windsor, Canada

The Engineering in a Curling Iron

What sort of engineering is it that makes a study of the needs and the interests of women and creates products to satisfy them? Does it seem that, in practice at least, this sort of thing is a little different from your understanding of what an engineer really is and does?

After all, when you come to think of it, engineering is concerned with all the facts of life. It takes the old facts and interprets them in new and broader ways; but its big job is the very big job of making more living, —fuller living,—readily available. It is, in every aspect, a thing worth doing, whether it concerns itself with curling irons or converters, or any of the thousands of products in between.

This is truly the day of the engineer. His judgments and his equipment are sought in almost every phase of living. Engineering is remaking the business of housekeeping. Its methods are being applied to merchandising, to distribution, to the wrapping of bundles and the packing of boxes, to the lighting of streets and the hundreds of things that, a few years back, were strictly "rule-of-thumb". By the time you are at work out in the world, there will be more—though there are only a few of them left.

Whatever is worth doing is worth engineering; engineering effort dignifies itself. Whether it puts more usefulness into transformers or curling irons or turbines does not matter. The thing that counts is the work, the creative, constructive service that is going on for the lasting benefit of mankind.

Westinghouse

ACHIEVEMENT & OPPORTUNITY

W WESTINGHOUSE ELECTRIC

THE APPLICATION OF COLOR IN INDUSTRY

(*Continued from page 239*)

analyst of color is the conduct of research: (1) to determine and correct the cause of errors-of-result in process; (2) to simplify and economize on materials and standardize them more perfectly; (3) to arrive at the simplest and most fundamental means of detecting mistakes in process and to anticipate these early in the process stage before excessive cost has been applied to the product and (4) to design and construct special control devices adaptable to the peculiar needs of the product they are to classify and standardize. There is a fifth demand that is made now, and with the increased public appreciation of materials in tasteful coloring, this demand bids fair to inspire an effort far exceeding the other four types of research. This effort must invade, almost at once, the realms of pure science and psychology, as it is from these that much of its context has been derived in the earlier stages of its progress. The determination of what combinations of coloring are effective, fitting to a given situation, and harmonious, may well occupy the limit of energy and stimulate courageous investment on the part of the future manufacturer of any sort of colored product, from barn paint to millinery. Fortunately there is a good background from which to proceed — the errors of the past on this line should and do furnish the well equipped mentality, acquainted with all phases of the problem, with abundant material from which to derive his conclusions and declare the laws which govern this situation.

The ever-changing third demand upon the colorist is that for specific applications to works problems, and judgment of policy in the conduct of displays, combinations, patterns, mixtures, style, etc. This demand includes everything from a means to determine the initial colors that made up a heather mixture to exact specifications for the proper brown (out of a group of ten brown samples) likely to be most seasonable.

Some accomplishments already realized which come under this general division are as follows:

1. Determination of exact amount of a given color to make a nearly white paint exactly white.

2. The selection of the proper ones of two reds and blues to produce a given purple.

3. Selection of materials having the proper physical properties, size, grain-structure, etc., to produce a given (mixture) color.

4. Rating of the relative dyeing power of two dyes.

5. Selection of dyes having greatest concentration and tinting power (for a given hue) from among large group offered.

6. Determination of maximum color of raw stock in paper which will display a given tint printed upon it without degrading it.

7. Establishment of artificial fastness standards of dyes which are exactly comparable to fastness to natural sunlight.

8. Specification of color in form capable of transmittal without use of accompanying sample.

9. Calculation of percentages of woven color mixture to create an altogether new (resultant) color from the elements involved.

10. Establishment, in imperishable repeatable standards, of whites, blacks and colors, for reference points in standardization.

11. Service work to consumers of house furnishing materials, the recommendations for arrangement, selection

(*Continued on page 260*)

Watch the Man with the Advertising Idea

—He may be the coming brains of your business

LOOK over the young executives who direct the building and the manufacturing businesses of the country. A surprisingly large percentage of them have reached their goals by advocating advertising, by directing the advertising and by making the advertising work.

If yours is a business which doesn't advertise, don't close your ears to the story of your young men. Help them to think it out—listen to their plans and their hopes. Add the counsel of years of experience to the minds of the men who are planning the future of your business.

Did you ever expect that iron could be advertised profitably? Few advertising men did. Did you ever expect to eat trademarked grapefruit? It is an accomplished fact at thousands of breakfasts this morning. Did you ever think the dairymen could profitably use the forces of publicity, or that a barber shop could grow to twenty-five, largely by the power of the printed word and an ideal of service.

The coming executives realize that a business exists, in the last analysis, in the minds of its customers, rather than in four walls and a roof, and, perhaps, that is why they are the coming executives.

Published by THE TECH ENGINEERING NEWS
in co-operation with The American
Association of Advertising Agencies

Iron and Emery Cast Together!

FERALUN
Anti-Slip Treads

Approved by
Underwriters Laboratories & Casualty
Liability Insurance Companies

When making details or writing specifications it is well to have in mind some of the important applications of **Feralun.**

Coal Hole Covers
Area Covers
Gutter Plates
Elevator Door Thresholds
Freight Elevator Landings
Floor Plates
Ramps
Stair Treads { Superimposed / Inserted / Complete
Trench Covers
Shipping Platforms
etc. — etc.

For tread surfaces of more distinction and beauty and particular qualities, bronze and aluminum are used instead of iron as the metal into which the abrasive is cast.

Send for Samples

AMERICAN ABRASIVE METALS CO.
50 CHURCH STREET, NEW YORK CITY

MEASURING UP TO A FAMOUS NAME

NINETEEN years ago, the Wrights made their first flight. Since that time the name "Wright" has been synonymous with aviation. 1923 begins the twentieth year of contributions to the art of flying by the organization bearing the Wright name and carrying on the Wright traditions.

The Wright organization has maintained and is maintaining a thoroughly organized and carefully equipped Engineering and Experimental Department, which is constantly engaged in the improvement of the Wright product.

A trained production organization, with the best of facilities, is working in close cooperation with its Engineering Department, and regularly producing developed Wright products. This organization and its facilities are ready to meet any normal requirement or emergency.

WRIGHT AERONAUTICAL CORPORATION
PATERSON, NEW JERSEY, U.S.A.

The identification of "Incomparable Service"

WRIGHT

APPLIED COLOR

(*Continued from page 258*)

of colors, etc., being based upon known laws of color harmony. (These laws must be known or the attempt is presumptious and involves risk.)

12. Extension of the "line" of plain colors adaptable to such a product as automobiles bodies

13. Elimination of superfluous colors from a line, such as duplicates and near-duplicates.

14. Adjustment of the color work of an advertisement to represent truthfully the color and patterns of the product it displays.

15. Adjustment of process-color to accord exactly with an artist's sketch, so that none of the beauty of a composition may be lost through transfer from art to industry.

16. The development of increased markets for a product, through exact knowledge of the color-adaptability and exactness of the product.

The complete list of these accomplishments is a formidable one and is growing each day.

The preliminary survey necessary to the establishment of product and quality control by means of color and other physical measurement presents an unusual opportunity for a coincident economic survey of the problem as a whole, previous to the expenditure of a single dollar on any of the established details mentioned above.

The research itself will benefit by being upon such a budgeted basis because this will obviate later discussion of details regarding purchases of apparatus and policy of operation of the project.

The background (literature of) and methods of physical measurement are so thoroughly worked out along many lines as to permit of practical application with the presentation of the demand therefor, and the manifold demands of a whole business are always better served from such a background than if the work is applied only to a production department.

The chief reason for this is that, while this work may seem, at first glance, to be a problem affecting only the product, a broader survey of the business as a whole will immediately establish its inescapable linkage with the good will and the advertising message, the advertising appeal, the market trend, the possibilities for development of market, indeed the whole fame and hope of future progress of a business, because whereas this is, no doubt, a problem of the product, it is also inevitably the problem of all the departmental elements of the business.

Furthermore, it may safely be asserted that an overwhelming majority of the research activities initiated in industries not only make no attempt whatever to presage the position which they are to occupy in their inter-departmentally organized industry, but scarcely a one either starts out or works later on the basis of the budgeted balance sheet, viz.:

"That for a given investment of time, brains, apparatus, space occupied and material and energy expended (and encountered in opposition!) a satisfactory profit will be obtained."

There is more hope of visualizing such results previous to the establishment of physical methods of control than from any of the other sciences now in use, and it is chiefly because the material of this science is so well in hand and adaptable to the service of the properly grounded advisor of this survey.

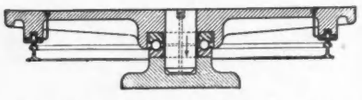
Indeed, so concrete and clearly defined have many of the problems (and the means offered for their solution) become that a specialized background of experience in this field is the sole requisite to success in the solution of many of the most vexing details affecting quality of output. It is frequently possible to state with confident exactness the course to follow, and correction in process to make, in order to improve the standard of a quality, and not to be obliged to have recourse to a single piece of expensive apparatus to qualify the answer. In fact, expensive apparatus is for difficult research and fundamental standardization of method — decision on the intimate details of the daily problem is founded on knowledge of the background from which this science (and art) has sprung.

Recent experiments in transoceanic radio work using the new 20 Kw. water-cooled vacuum tube have proved successful and it will probably place the high frequency alternators in use at the present time.

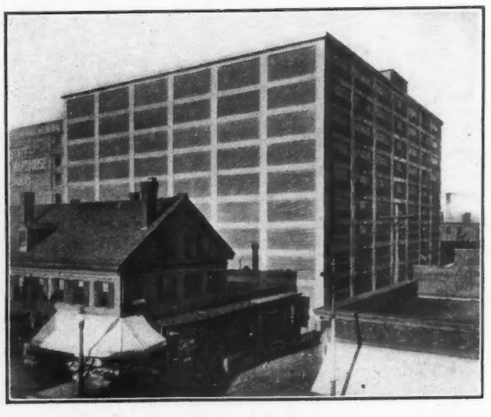
Turn Tables move easier
on
AUBURN THRUSTS

Turn Tables and other slow moving machine parts are turned easily under the heaviest loads when Auburn Ball Bearings are installed to reduce the starting friction. Mail sketch of your problem and get the Auburn Answer. Data sheets sent on request.

Steel, Brass and Bronze Balls



AUBURN BALL BEARING CO.
44 Elizabeth Street
Rochester, New York, U. S. A.



WILLIAM T. REED CO.

Building Construction

200 DEVONSHIRE STREET, BOSTON

We are organized and equipped for the efficient handling of mercantile and industrial building construction of all descriptions

Formerly New England Concrete Construction Company

Industrial Printing

THE MURRAY PRINTING COMPANY is located at Kendall Square, Cambridge, in its own modern and commodious building, with a plant that is efficient in every detail. The firm has been established one-quarter of a century and handles the printing of catalogues, periodicals and technical books. The firm's list of customers includes many large manufacturers and publishing houses of New England.

Always ready to intelligently coöperate with you on your printing requirements

THE MURRAY PRINTING COMPANY
KENDALL SQUARE, CAMBRIDGE

No headaches

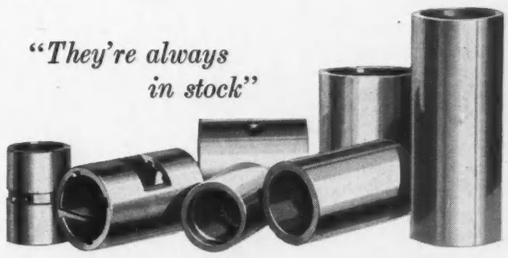
where Atlas Ammite is used

Atlas Ammite Explosive *will not cause headaches* from handling. Think what this means to blasters who have endured for years the sickening headaches caused by certain kinds of dynamite.

Atlas Ammite is an "all-'round" explosive. It is made in different grades to suit various conditions; it has abundant power and is safe to handle.

ATLAS POWDER CO.
WILMINGTON, DELAWARE

"They're always in stock"



BUNTING BUSHINGS
PATENTED

Here's The Bushing You're Looking For

Somewhere in the 154 different sizes of Bunting Ready Made Bronze bushing bearings you will find bushings that fit the requirements of your present need. You may have to change some dimensions slightly but the experience of most manufacturers and designers is that Bunting's "In Stock" bushings include everything ordinarily required in any kind of machinery. You can get Bunting Ready Made bushing bearings as you need them, when you need them and in any quantity.

The manufacturer in small production and the repairman appreciate the fact that they can buy small lots at long run prices. Every bushing is completely machine finished ready for assembly. All are made from genuine Bunting Phosphor Bronze.

Stock list 1 shows sizes and prices of 154 plain bronze bushing bearings for general industrial machinery. Write for it.

Stock list 28 shows Ready Made Piston Pin bushings for all popular cars, trucks, tractors and motors. Write for it.

Counsel and quotations on any special requirement. Pattern and Tool Equipment for over 10,000 different designs.

The
Bunting Brass & Bronze Company
715 Spencer Street
Toledo, Ohio

BOSTON
36 Oliver Street
Main 8488

NEW YORK CITY
245 West 54th Street
Circle 08444

CHICAGO
722 South Michigan Avenue
Wabash 9153

CLEVELAND
1362 East Sixth Street
Main 5991

SAN FRANCISCO
198 Second Street, corner Howard
Douglas 6245

THE MEASUREMENT OF PERSONALITY AND INTELLIGENCE

(*Continued from page 236*)

him. The test makes it possible to make a satisfactory analysis of the main causes in any case of delinquency. The man with a low score is warned that his college work will involve more mental tension than for most men, and he is accordingly advised early in his college course to limit his extra-curricular activities. On the other hand the man of exceptionally high score may be safely urged to attack a full schedule of hard courses. Not all of these men will become experts, scientists, or learned professional men, but they will furnish by far more than their share of them, and it is decidedly to their advantage and that of society to bring them to the realization that they are the best hope of intellectual leadership in their communities, if they will only make the best of their opportunities.

In industry the most promising uses of mental alertness scores have been in the classification of learners in factory schools and in the determination of the causes for inefficiency or dissatisfaction of men on the job: The two important facts to know are the alertness level of the average man at any given type of work and the alertness level of the individual whose case is being studied. It has been clearly demonstrated that if a man's alertness level is much higher than that of the average man working at his job, it is extremely likely that the man will have the dissatisfaction of feeling that he is in a blind alley. On the other hand, if his mental alertness level is decidedly below the average for his type of work, he will almost certainly prove an inefficient workman. The minute specification of jobs in terms of fitness at special tests, such as was attempted with some success during the war, can probably never be satisfactorily accomplished except with routine processes and in very large scale production. The vast numbers of workers in munitions plants during the war afforded some promising experiments in the selection of the most likely assemblers, gaugers, and clerical workers on the basis of tests which showed an especially high correlation with performance at special jobs, but these industrial conditions will probably not be duplicated.

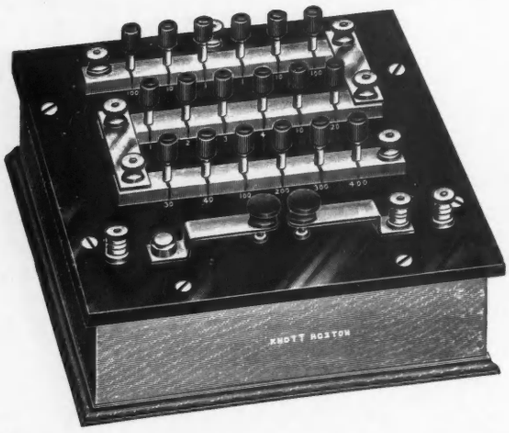
The measurement of personality had its crude beginnings in the self-analysis chart. The individual either rated himself on a number of traits or gave answers to a questionnaire in which he was asked to state in some detail how he would react to a considerable number of situations. The obvious defect in such a method was the impossibility of getting any man to completely free himself of defense mechanisms in such a rating scheme. Every man is more or less of a hero to himself, however low an estimate others may place on him. It is even doubtful whether many men could be mathematically accurate in stating their average golf score.

A distinct advance was made with the method of rating by judges, an example of which was the officers' rating cards in the army. Such ratings, when made out carefully by a sufficient number of competent judges, afford an approximate estimate of what to expect of a man in situations involving such traits as leadership, reliability, or originality. In practical use they are likely to suffer from the incompetency of judges, the insufficiency of data, or from a too literal interpretation on the part of those who use them.

The ideal method of measuring personal traits is one that employs objective tests, subject to experimental

(*Continued on page 264*)

In Resistance Measurements



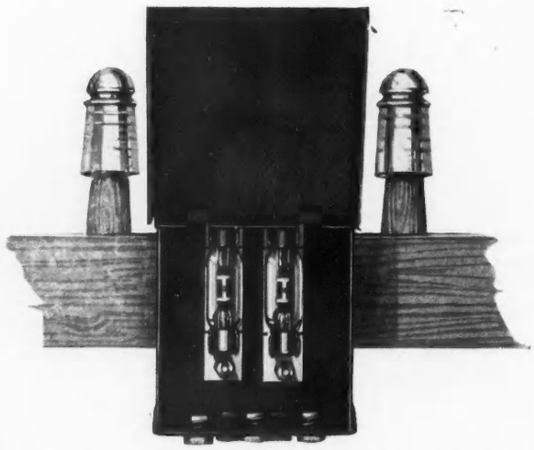
Secure a high degree of accuracy by using the Improved Combined Bridge and Resistance Box. Measurement range from .01 to 111,000 ohms.

CATALOGUE ON REQUEST

L. E. Knott Apparatus Company

Scientific Instrument Makers

CAMBRIDGE, MASS.



Operating engineers—particular in safeguarding their property—always specify

VAC-M ARRESTERS

IN

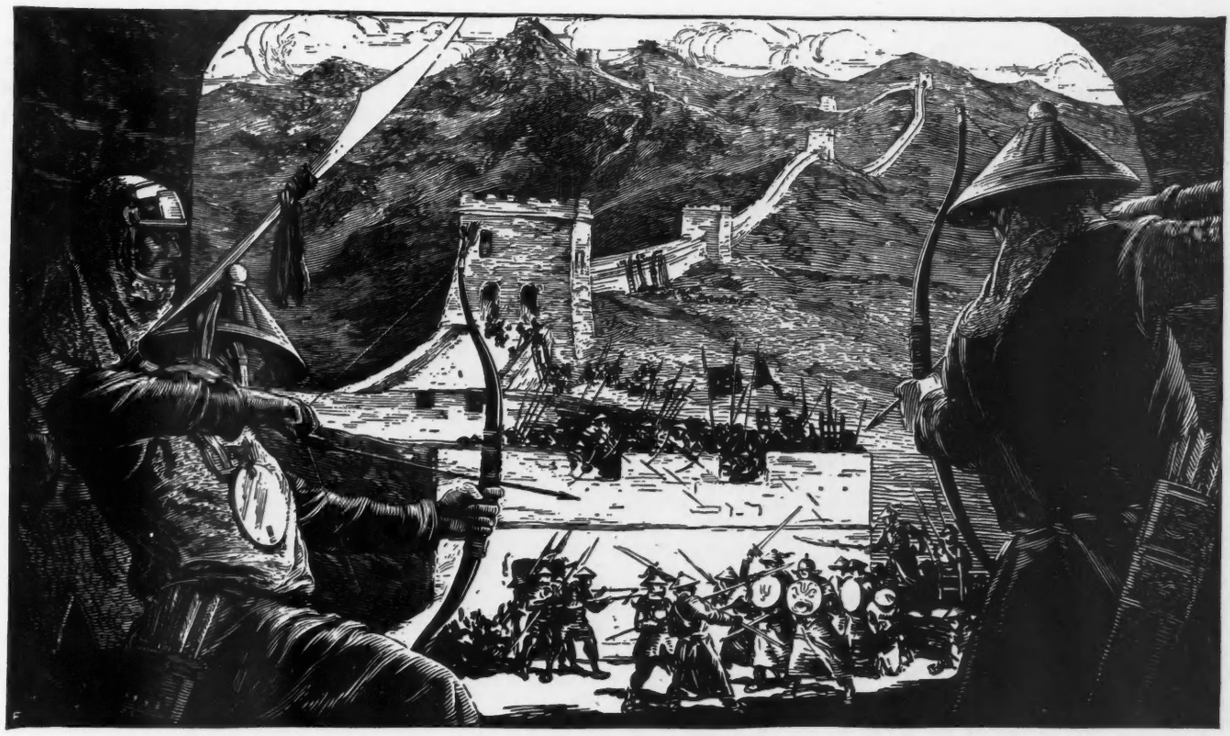
VAC-M CONTAINERS

for the protection of low voltage circuits because with them they can have uninterrupted service; intact equipment; positive protection against static; lightning; crosses; and grounds.

Write for details

National Electric Specialty Co.

Toledo, Ohio



The Great Wall of China

To stop the inroads of the barbarians of Northern China, Chin Huang-Ti in 214 B.C. began building the Great Wall of China.

Brawn was nearly the only force at his command to accomplish this enormous task. He gathered together an army of 300,000 men and set them at laboriously hewing out the stone for the faces of the wall and gathering rubble to fill in the inside.

Generation after generation of Chinamen toiled on the structure. Another dynasty arose and continued the work. Even as they labored, they were often called upon to repulse the attack of some hostile horde. The Great Wall still stands, one of the most remarkable achievements of human strength and persistence.

The cost of time and labor was immaterial to the Chinese Emperor, Chin Huang-Ti, but to the modern road builder, contractor quarryman or miner, these two factors are of great importance.

Explosives have been one of the principal factors in reducing the stupendous production costs of bygone ages, but the necessity for eliminating waste has become so urgent that even dynamite, perhaps the greatest labor-saving invention of all history, must now be scientifically selected. It is possible to reduce blasting costs with Hercules Special No. 1 on work for which it is suited. This explosive contains about ⅓ more cartridges per case than ordinary dynamite and usually replaces 40% dynamite, cartridge for cartridge, at a saving of 25% or more in blasting costs.

Our booklets, "Volume vs Weight" and "Eliminating Waste in Blasting," tell why Hercules Special No. 1 and Special No. 2 are so economical. Write to our Advertising Department, 939 King Street, Wilmington, Delaware, for free copies of these booklets.

HERCULES

POWDER COMPANY

Allentown, Pa. *Birmingham, Ala.* *Buffalo, N. Y.* *Chattanooga, Tenn.* *Chicago, Ill.* *Denver, Colo.* *Duluth, Minn.* *Hazleton, Pa.* *Huntington, W. Va.* *Joplin, Mo.* *Los Angeles, Calif.* *Louisville, Ky.* *New York City* *Norristown, Pa.* *Pittsburg, Kan.* *Pittsburgh, Pa.* *Pottsville, Pa.* *St. Louis, Mo.* *Salt Lake City, Utah* *San Francisco, Calif.* *Wilkesbarre, Pa.* *Wilmington, Del.*

PERSONALITY

(*Continued from page 262*)

control, as are the mental alertness tests. Beginnings have already been made in this field, and the results are most promising. A single example will suffice to indicate the type of test employed. An experiment in which the subjects were required to return the fixed gaze of an instructor while performing a series of mental additions at maximum speed showed that subjects who had been consistently rated as lacking in personal force made twelve times as many evasive eye movements as did the subjects who had been rated as conspicuously forceful. In another part of the same experiment the subjects rated as forceful were more than three times as capable of controlling their attention in spite of fear distraction as were the subjects rated low in forcefulness. The attention control was measured in terms of their ability to maintain their normal speed at mental addition. The fear distraction was obtained by the use of such stimuli as a 75-volt electric shock coming at the end of each additional series or the passing of a dead snake a foot in front of the face during the adding. The scores resulting from the above test indicated an average of 93 for thirteen forceful subjects as compared with an average of 59 for the subjects lacking in this trait.

When objective personality tests have made as much progress as have the intelligence tests, it is the belief of even the most conservative psychologists that applied psychology will have a large field of use in both education and industry. It is even now in a fair way to contribute valuable service wherever men have to be dealt with in groups rather than individually.

ENGINEERING LABORATORIES

(*Continued from page 235*)

fifteen thousand three hundred square feet of floor space and, in addition to the steam-driven equipment referred to in the Hydraulic section, has fourteen engines of various types and sizes, among which may be mentioned a triple expansion Reynolds Corliss engine and a McIntosh and Seymour tandem compound engine.

All of these engines with the exception of the marine engines and those used for valve setting are connected with surface condensers in the basement. These condensers are supplied with cooling water taken from one canal in the basement and discharged into a second canal which overflows into a thirty-inch pipe leading back to the river.

Throughout the basement of the Steam and Hydraulic sections canals from two to eight feet in width extend from one end of the laboratory to the other. The length of these canals is about seven hundred feet. The canals are cross connected and are arranged with stop logs so that different levels may be maintained in different parts of the system. The canals are supplied with water through a thirty-inch main leading from the river; there are also two fourteen-inch connections. The bottom of the shallowest canals is fourteen inches below river level. The suction wells for the pumps are connected with the canal system.

During the months of August and September a fire-proof building one hundred and fifty feet by thirty-five feet was erected by Technology to house the high pressure air compressors and the refrigerating machines which have been operating in the main buildings. This building contains three high pressure three-stage compressors, two ammonia compression machines both of one-ton capacity, a five-ton Carbondale absorption machine, as well as a number of special condensers, brine coolers, etc., used in connection with experiments on heat transmission.

The Power Measurement section, where tests are made on dynamom-

(*Continued on page 266*)

GENERAL WELDING & EQUIPMENT CO.
G W & E C O
74 BROOKLINE AVENUE, BOSTON, MASS
WELDING AND CUTTING EQUIPMENTS
AUTOMATIC CUTTING MACHINES

Burton-Furber Coal Co.
—
Sole Retail Agents
Crozer-Pocahontas Coal
Selected Grades of
ANTHRACITE COAL
—
50 CONGRESS STREET
BOSTON, MASS.

McMAHON & JAQUES
242 Massachusetts Avenue
Boston
Lock and Electric Work
Plumbing Heating and Lighting
HARDWARE, PAINTS AND OILS

DAYLIGHT ILLUMINATION.

The angle of refraction being equal to the angle of incident, it is a simple matter to determine the correct angles to use in manufacturing glass which will give good illumination. But for proper industrial plant illumination, there is more to be considered than mere deflection of light. The direct beam of light must be eliminated in order to prevent sun glare, which is objectionable on account of its causing heavy shadows and strong contrasts which decrease the efficiency of employees and necessitate the use of shades which in turn reduce the light to such an extent that daylight illumination any distance from the light source is not sufficient. Therefore, in order to produce a glass which when used in the windows of industrial plants will produce as near to ideal illumination as possible, we must first eliminate the direct rays of the sun by deflecting the light to the ceiling and side walls which re-deflect it back to a distance 25 to 50 feet from the window throughout the entire working area. To accomplish this we have scientifically designed a type of glass which is named "Factrolite."

Factrolite consists of 30 ribs to the inch, running at right angles, forming 900 pyramidical prisms or 3,600 light deflecting surfaces which completely disintegrate the direct beam of light from the sun. Furthermore, the depressions in the surface of Factrolite are so slight that the accumulation of dirt and dust is minimized and can be perfectly cleaned with an ordinary dry scrubbing brush. Incidentally, the cleaning of windows is most important for keeping up production and increasing the efficiency of any industrial plant and should be given more consideration in plant management.

If you are interested in the distribution of light through Factrolite, we will send you a copy of Laboratory Report—"Factrolited."

MISSISSIPPI WIRE GLASS CO.,
220 Fifth Avenue,
St. Louis. New York. Chicago.

and Now—

A Six-Inch Rule
(Pocket Size) of
STAINLESS STEEL
by
BROWN & SHARPE

RUST PROOF—will not stain or discolor, but will always retain its bright finish—clean-cut graduations in 8ths, 16ths, 32nds and 64ths, of the characteristic Brown & Sharpe accuracy.

Get one from your dealer today
Ask for No. 350—You'll like it

B·S

BROWN & SHARPE MFG. CO.
Providence, R. I., U. S. A.

ENGINEERING LABORATORIES

(*Continued from page 264*)

eters, on torsion meters, on balancing, on the transmission of power by belts, on critical speeds, etc., has been transferred from the third floor of Building Three to the basement of the Pratt Building and will be reassembled during the winter.

The Gas Engine section is housed in two buildings, located about five hundred feet from the main group of educational buildings. One of these buildings, a two-story building forty feet by eighty feet on Vassar Street, contains a fifty horse power Diesel engine, a two hundred horse power marine engine, a four-cycle gas engine of thirty-six horse power, a Nash engine with Galusha gas producer, a G. E. generating set, hot air engines and oil engines.

The other, a building ninety feet by forty feet was erected in October, 1921, to house about twenty-five hundred horse power of gasolene engines of the types used by the Ordnance Department of the United States Army.

The equipment of the Ordnance Internal Combustion Engine Laboratory consists of Sterling, Liberty, Cadillac, Dodge, Holt, Ricado, and Van Blerck engines, of which there are four each save for the Ricardo and Van Blerck, there being two of the former and one of the latter. A Ford tractor has been loaned by the Ford Company.

The Textile Section, covering twenty-two hundred square feet of floor space, contains a complete equipment of modern machinery such as is used in the manufacture of cotton cloth.

It contains also a Textile Testing laboratory with equipment as listed:

A Parks-Cramer humidifying system with automatic control.

An Emerson electric conditioning oven with thermostatic control and equipped with balances so that weighings may be made without opening the oven or removing specimens.

Four Scott testing machines as follows:

(a) Vertical Yarn Machine (0.50 pounds capacity).

(b) Vertical Fabric machine (150–300 pounds capacity) (with autographic recorder).

(c) Horizontal Fabric machine (400–800 pounds capacity).

(d) New Fabric machine (85 pounds capacity) (inclined plane dynamometer type).

A Becker Analytical Balance (weighing to 0.01 grain).

In addition, the usual complement of measuring, counting and cutting apparatus necessary for the carrying out of textile tests.

The laboratory is of about five thousand cubic feet capacity, with heavy concrete walls and floors and tight doors and windows

It was said recently by an engineer who was familiar with the laboratories of Europe and who had just completed a tour through the laboratories of the leading colleges of America that the Engineering Laboratories of the Massachusetts Institute of Technology taken as a whole were the most complete of any he had seen.

BEMIS BRO. BAG CO.
CLOTH AND PAPER SACKS
ALBERT FARWELL BEMIS, '93, President
D. BELCHER, '09 P. E. MORRILL, '14 P. McCULLOUGH, '14
A. H. CLARKE, '15 T. W. LITTLE, '16 H. P. CLAUSSEN, '16
J. R. HUNNEMAN, '16 C. W. LOOMIS, '17

THE ANGUS COMPANY, Ltd., Calcutta
J. W. CAMPBELL, '17 C. H. TALCOTT, '21
M. W. ADAMS, '18 R. McKAY, '21

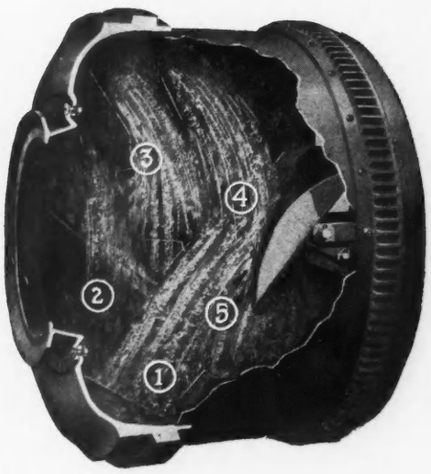
STARKWEATHER & BROADHURST, Inc.
Engineering and Contractors for
Power Plant Apparatus
TELEPHONE CONGRESS 1810 79 MILK STREET, BOSTON

Established 1870 Incorporated 1890
THE WARREN SOAP
MANUFACTURING COMPANY
Textile Soaps
77 SUMMER STREET BOSTON, MASSACHUSETTS

SAMSON SPOT SASH CORD

Trade Mark Registered U. S. Patent Office
Made of extra quality cotton yarn, carefully inspected and guaranteed free from all imperfections of braid or finish. The colored spots are our trade-mark, used only with this quality.
We make braided cord of all sizes, kinds and colors, for all purposes, including sash cord, clothes lines, trolley cord, signal cord, arc lamp cord, and many special cords for special purposes.
CATALOGUE AND SAMPLES GLADLY SENT ON REQUEST
SAMSON CORDAGE WORKS 88 Broad Street, Boston 9, Mass.

Dominant Strength Concrete



(1) Blade cuts through materials with churning action. (2) Blade carries materials up, spilling down again against motion of drum. (3) Materials hurled across diameter of drum. (4) Materials elevated to drum top and cascaded down to reversed discharge chute which (5) with scattering, spraying action, showers materials back to charging side for repeated trips through mixing process.

SAME cement—*same* aggregate—*same* water—yet compression tests show a wide range of strength in the concrete as mixed by different mixers. Koehring mixed concrete consistently rates strongest on compression tests.

For strongest structures; *cement* and *aggregate* according to specifications of American Society for testing materials.

Water—of controlled quantity and quality.

Mixing—the Koehring five action re-mixing principle which *prevents* separation of aggregate according to size, and delivers uniform concrete to the last shovelful of every batch.

KOEHRING COMPANY
MILWAUKEE WISCONSIN

KOEHRING
HEAVY DUTY

KOEHRING

THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY

CAMBRIDGE, MASS.

THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY aims to give thorough instruction in Civil, Mechanical, Chemical, Mining, Electrical and Sanitary Engineering; in Chemistry, Electro-chemistry, Architecture, Physics, Biology and Public Health, Geology, Naval Architecture and Engineering Administration.

To be admitted to the Institute, the applicant must have attained the age of seventeen years and must pass examinations in Algebra, Plane and Solid Geometry, Physics, Trigonometry English, French or German. Certificate of preparation in two units of a series of elective subjects is also required. The requirement in History may be met by the presentation of a school record of certificate grade. A division of these examinations between different examination periods is allowed. In general a faithful student who has passed creditably through a good high school, having two years' study of French and German or three years of French or German should be able to pass the Institute examinations.

Graduates of colleges, and in general all applicants presenting certificates representing work done at other colleges, are excused from the usual entrance examinations and from any subjects already satisfactorily completed. Records of the College Entrance Examination Board, which holds examinations at many points throughout the country and in Europe, are also accepted for admission to the Institute.

Instruction is given by means of lectures and recitations, in connection with appropriate work in the laboratory, drawing-room or field. To this end, extensive laboratories of Chemistry, Physics, Biology, Mining, Mechanical Engineering, Applied Mechanics, and the Mechanics Arts have been thoroughly equipped, and unusual opportunities for field-work and for the examination of existing structures and industries have been secured. The coöperative course in Electrical Engineering and that in Chemical Engineering Practice afford an unusual opportunity to combine a technical training with a direct contact with the industries.

The regular courses are of four years' duration, and lead to the degree of Bachelor of Science. In most courses the work may also be distributed over five years by students who prefer to do so. Special students are admitted to work for which they are qualified; and the degree of Master of Science, Doctor of Philosophy, and Doctor of Science are given for resident study subsequent to graduation. Opportunity for research is offered in all the departmental laboratories and in the Research Laboratories of Applied Chemistry, Electrical Engineering, Industrial Physics and Physical Chemistry.

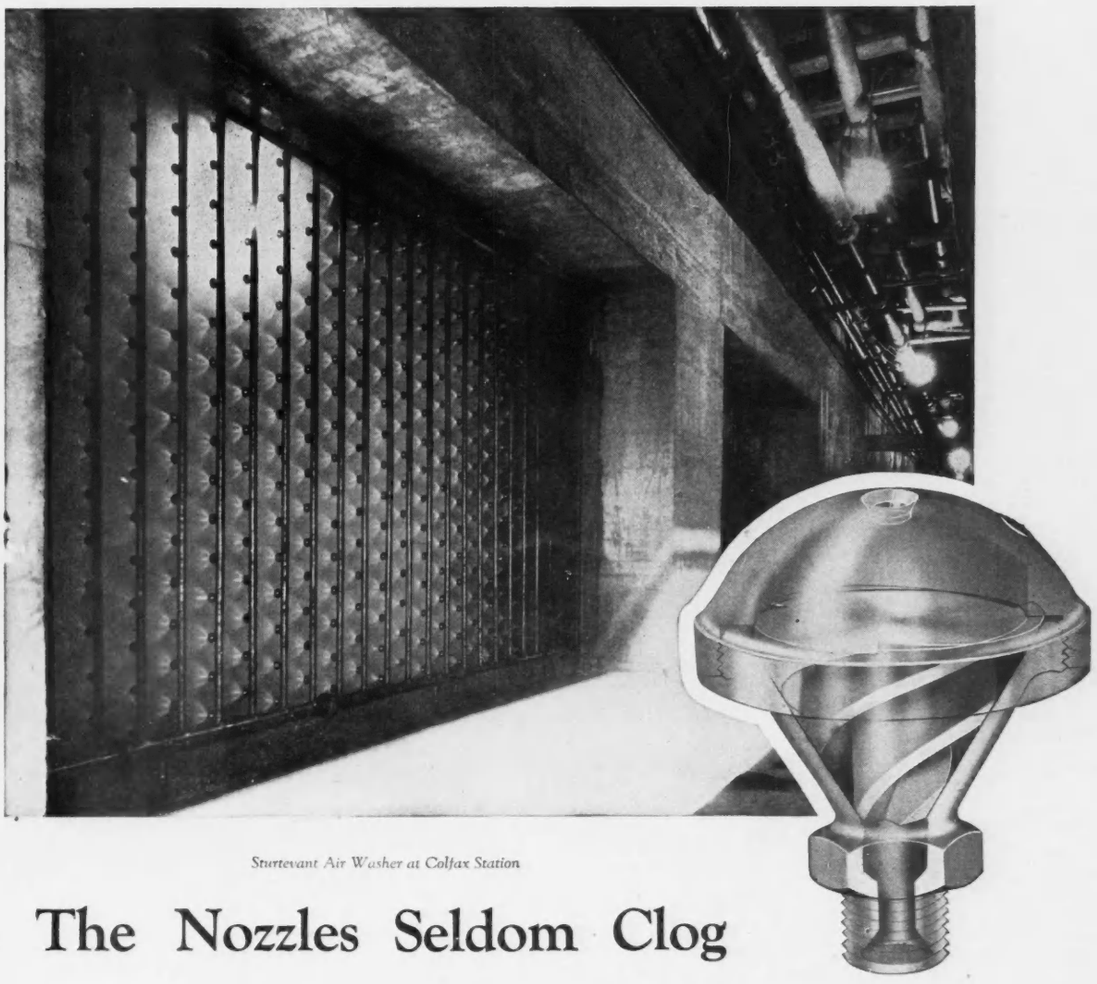
The tuition fee, not including breakage in the laboratories, is $300 a year.

For catalogues and information, address

ADMISSIONS OFFICE,

MASSACHUSETTS INSTITUTE OF TECHNOLOGY,

CAMBRIDGE 39, MASS.



Sturtevant Air Washer at Colfax Station

The Nozzles Seldom Clog

New York reports that only seven nozzles out of 230 needed cleaning after three months' operation of the Sturtevant Air Washer for Generator Cooling.

Now comes Colfax, reporting that only three nozzles out of 350 had to be cleaned after nine weeks' service—both installations using recirculated water.

Similar gratifying results are shown wherever such apparatus is installed. Sturtevant engineering and construction? Yes, plus that wonderful improved nozzle which is exclusive to Sturtevant Air Washers.

Bulletin 246—on Generator Cooling—a handsome, well-illustrated twenty-eight page bulletin is yours for the asking; write for your copy today.

The marked success of Sturtevant Systems wherever installed, is, in a large measure due to this improved nozzle. It is exclusive to Sturtevant Systems. This nozzle gives a dense, well-atomized, uniform spray. It will operate for long periods, even with dirty water; it can be cleaned whenever necessary while the system is in operation.

B. F. STURTEVANT CO. BOSTON U.S.A.

REG. U.S. PAT. OFF.

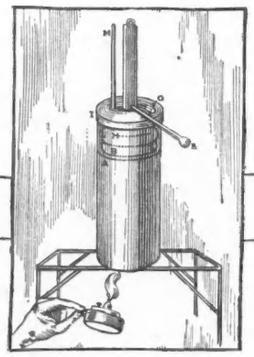
Sturtevant

PUTS AIR TO WORK

HYDE PARK,
BOSTON, MASS.

686

DENIS PAPIN'S STEAM CYLINDER



They Weighed Air— *and* Charles II Laughed

SAMUEL PEPYS says in his diary that Charles II, for all his interest in the Royal Society, laughed uproariously at its members "for spending their time only in weighing of air and doing nothing else since they sat."

This helps to explain why Charles has come down to us as the "merry monarch."

The Royal Society was engaged in important research. It was trying to substitute facts for the meaningless phrase "nature abhors a vacuum," which had long served to explain why water rushes into a syringe—the commonest form of pump—when the piston is pulled out.

Denis Papin had as much to do as anyone with these laughable activities of the Royal Society. Papin turned up in London one day with a cylinder in which a piston could slide. He boiled water in the cylinder. The steam generated pushed the piston out. When the flame was removed, the steam condensed. A vacuum was formed and the weight of the outer air forced the unresisting piston in.

Out of these researches eventually came the steam engine.

London talked of the scandalous life that King Charles led, and paid scant attention to such physicists as Papin, whose work did so much to change the whole character of industry.

The study of air and air pumps has been continued in spite of Charles's laughter. In the General Electric Company's Research Laboratories, for instance, pumps have been developed which will exhaust all but the last ten-billionth of an atmosphere in a vessel.

This achievement marks the beginning of a new kind of chemistry—a chemistry that concerns itself with the effect of forces on matter in the absence of air, a chemistry that has already enriched the world with invaluable improvements in illumination, radio communication, and roentgenology.

General Electric Company

General Office *Schenectady, N.Y.*

95-632D

TECHNOLOGY PRESS, CAMBRIDGE, MASS.